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ABSTRACT

This guide is intended to assist the teacher in exploring energy issues and the technology of solar energy conversion and associated technologies. Sections of the guide include: (1) Rationale; (2) Technology Overview; (3) Sun Day Suggestions for School; (4) Backyard Solar Water Heater; (5) Solar Tea; (6) Biogas; (7) Solar Cells; (8) Economics; (9) Sundials; (10) Activities for Elementary Schools; (11) Activities for Secondary Schools; and (12) a bibliography and source listing for energy education materials. Other topics are covered in detail within the 19 chapters of the guide. (RE)

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SOLAR '80s

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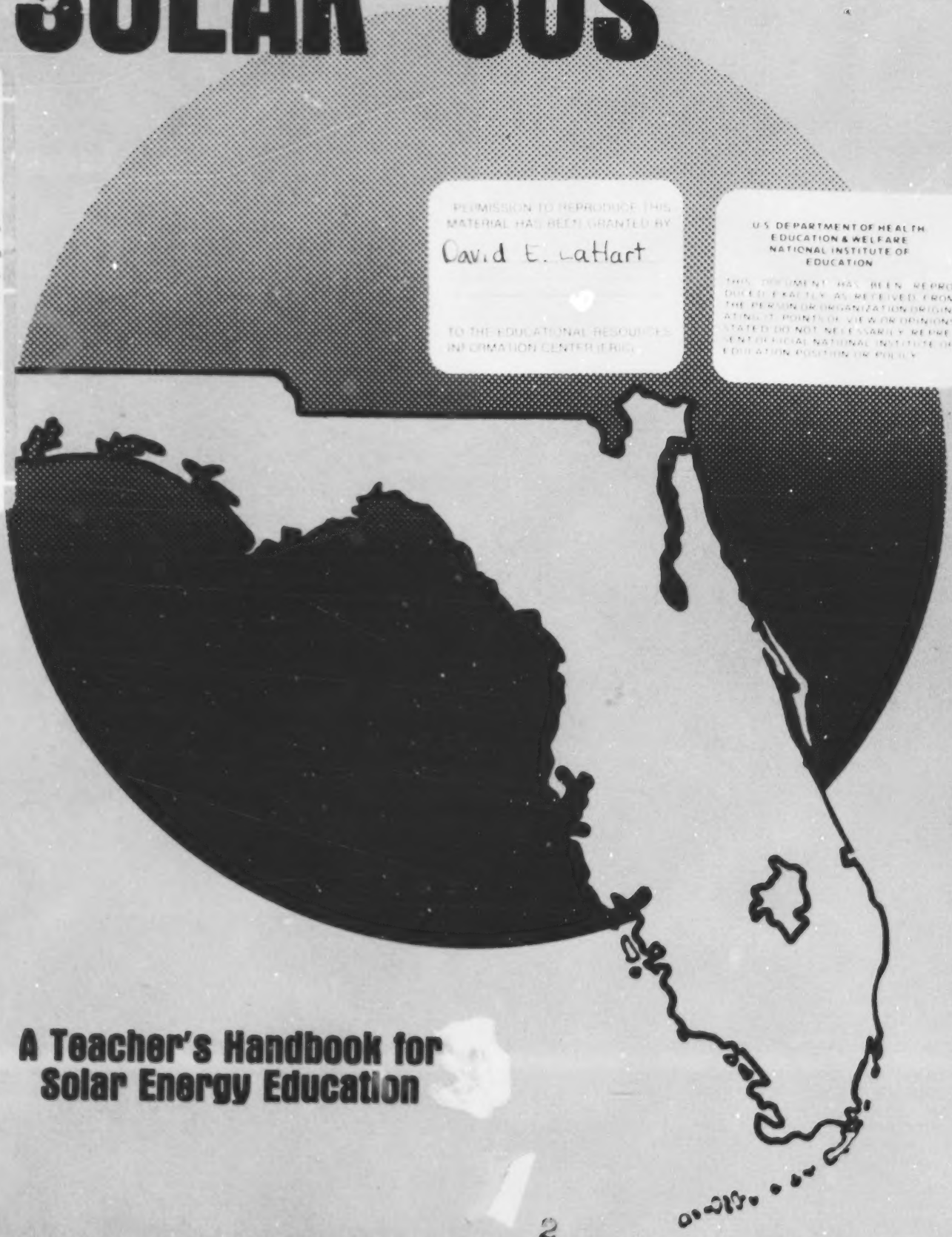

A Teacher's Handbook for Solar Energy Education

SE 030 943

SOLAR '80s

A Teacher's Handbook for Solar Energy Education

David E. LaHart
Technology Transfer Division
Florida Solar Energy Center
March 1980

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Table of Contents

Section		Page
	Foreword and Acknowledgements	
A	**Rationale**	A-1
B	**Technology Overview**	B-1
C	**Solar in Florida**	C-1
	by Jerry Ventre and Subrato Chandra	
D	**Sun Day Suggestions for School**	D-1
E	**Sunshine Quickies**	E-1
F	**Sun Search**	F-1
G	**A Backyard Solar Water Heater**	G-1
	by Stu Gleman	
H	**Investigating Solar Tea**	H-1
I	**A Solar Air Heater**	I-1
J	**Biogas**	J-1
K	**Making Parabolas**	K-1
L	**Investigating Solar Cells**	L-1
M	**Economics Worksheet**	M-1
N	**Sundials**	N-1
O	**Activities for Elementary Schools**	O-1
P	**Activities for Secondary Schools**	P-1
Q	**Bibliography**	Q-1
R	**Sources for Energy Education Information**	R-1

FOREWORD AND ACKNOWLEDGEMENTS

As Americans move into the 1980s, energy is becoming a major social issue. The problem is clearly defined: Six percent of the world's population is consuming 33 percent of the world's energy. Because of this, current energy shortages are but symptoms of a larger problem that has economic, environmental and ethical ramifications. Educators are being called upon to help the transition to a post-petroleum world. The crucial test is whether the change will be smooth--the result of careful preparation and planning, or chaotic--the result of a succession of worsening economic, social and political crises. We are examining our energy opportunities and should choose a path that will allow future energy options. Beginning to live on energy income instead of depleting the world's energy capital is a choice we can make today. Solar energy is a renewable resource that has long-term implications; by teaching our young people about its potential, educators can be instrumental in shaping our nation's energy future.

Solar '80s was a team effort. Parts of the text were reviewed by Subrato Chandra, Phil Fairey, Jerry Ventre and Doug Root. Their helpful comments initiated many technical changes and enhanced the quality of the text. Matt Brennan originated the units included in the elementary and secondary activities sections; they have been field-tested by many, many Florida teachers and are included here because they work!

Typing, retyping and retyping the manuscript was patiently handled by Cynthia Abrams; unique illustrations came from Jane Trancho; and Chuck Johnson skillfully edited and proofed the whole thing.

This project was completed because of the constant telephone calls of encouragement and support from Dick and Rosalyn Tillis. Without their prompting, Solar '80s would be just bunches of paper.

And now it's your turn. Please send your comments, corrections and suggestions to me for future editions.

With Sunshine
David E. LaHart
Cape Canaveral, Florida
March, 1980

RATIONALE

Introduction

The energy element of Florida's Comprehensive Plan aims to develop, wisely use and manage all forms of available energy to achieve a high quality of life for all Floridians, including future generations, and to sustain a long-term, stable and competitive state economy.

Six objectives have been selected to guide Florida's energy policy. They include:

a. An adequate, flexible, reliable, economic and environmentally sound future supply of energy for Florida.
b. Development and promotion of the most effective and efficient use of all forms of energy.
c. Management and use of energy supplies consistent with environmental quality and the health, safety, social and economic well-being of the public.
d. Reduction of the vulnerability of Florida's economy to rising energy prices and interruptions of supply, and the future transition to alternative energy sources.
e. Management and development of other physical, natural, economic and human resources to avoid unnecessary long-term energy-intensive investments.
f. Education of all citizens and decision makers about energy issues and development of a coordinated process for their involvement in energy-related decisions.

Objective f has special implications for the educational community. Although the complex and far-reaching nature of the energy situation demands citizen awareness of the problems and possible solutions, opinion surveys continue to reveal that large segments of the public remain unconvinced that a serious energy problem exists. If citizens fail to perceive a long-term energy problem, they are also unaware of the far-reaching economic and social implications involved. This unfor-

tunate attitude stems from a combination of factors including general distrust of government, partial information or misinformation, events of the moment (energy is available now), and past governmental efforts to isolate energy as a distinct technical issue without considering it as part of the "big picture."

Perhaps one of the most important needs is to educate and inform citizens about the entire energy situation--furnish them with useful, unbiased information which helps them cope with the situation today and provide them with a means of taking individual and group action to improve the situation tomorrow. When properly aware of the energy problem, citizens can assume individual responsibility for their actions and exert greater control over the choices being made.

Education and Energy

To help resolve this need, Florida has begun a major energy education effort which involves three broad interrelated areas:

1. Create and instill an "energy awareness" in Floridians.

Energy has been so abundant and inexpensive in the recent past that we are still accustomed to treating it as a "free" good. Much energy is wasted simply because people have not been educated to be aware of energy use. Energy use, like the use of other common resources, carries with it both rights and responsibilities. In a period of declining energy resources, energy consumers must understand the implication of their consumption patterns. Effective action in a democratic society depends on an enlightened and aware citizenry. The plan suggests these strategies for implementation:

a. Develop and introduce integrated energy, economic and environmental education programs into the curricula of the public schools, junior colleges, universities and continuing education programs.

b. Sponsor seminars, forums and workshops related to national and state energy issues.

c. Develop media programs (especially public service programming) to educate the general public.

d. Use the education resources of appropriate public and private organizations to develop and implement a statewide energy education program.

e. Develop and disseminate specific technical information (especially that specific to Florida) concerning energy conservation, alternative energy sources, and appropriate technologies.

2. Encourage citizens to undertake individual and group actions and provide them with the mechanisms to do so.

The magnitude of the energy problems confronting society tends to generate a feeling of powerlessness in many people. The problems seem so large or complex as to be beyond control, and the common response is to look to government, business and science for a solution. While the efforts of these institutions are necessary, it is equally important that individual citizens understand the actions they can take to deal with the day-to-day effects of the energy situation. Effective citizen action requires recognition of the limitations for institutional action and the assumption of individual responsibility to prepare for changes in energy supply and prices, and the resulting lifestyle changes. To implement this policy the plan suggests educators should:

a. Encourage and promote assistance programs which increase self-reliance.
b. Encourage educational programs that effectively provide basic and special skills.

c. Organize and initiate technical assistance and self-help programs.

d. Sponsor and demonstrate innovative energy conservation techniques and alternative energy and appropriate technology projects.

e. Emphasize identifying, evaluating and using less capital-intensive and energy-intensive technologies to provide a wide range of affordable and practical alternatives.

3. Improve the process for citizen involvement in government energy decision making.

One of government's major responsibilities in a democratic society is to keep citizens sufficiently informed to make decisions. Lack of information tends to promote a feeling of powerlessness, especially with the changing conditions of the energy situation. If citizens have sufficient opportunity to deal with social problems, a more stable transition to a workable solution can be achieved. Suggested strategies for implementation of this policy include:

a. Examine existing regulations and procedures regarding public participation in both public and private projects.

b. Continue to use and improve existing means of community involvement, such as the Regional Energy Action Committees and district environmental education contacts.

c. Encourage local governments to use citizen expertise and experience by creating or sponsoring citizen advisory councils on energy-related matters.

Paths for Energy Education

Once again educators, especially those in the public schools, are being called upon to ease the transition to a post-petroleum society. It is widely recognized that the energy challenge involves people who have not learned how to use finite amounts of energy within a biologically-sustainable limit. The problem is that 7 percent of the world's population uses 33 percent of the world's energy. We live in a country that is doubling its population every 70 years, doubling its petroleum use every seven years, and doubling its electrical consumption every 10 years. Understanding exponential growth is the key to understanding the energy challenge, because just increasing the amount of energy cannot keep pace with the growth rate of our energy appetite.

Educators obviously play a key role in determining our energy future. Preparing young people to make decisions has been a traditional goal of education, and energy decisions will have long-term effects. Since all energy technologies involve risks, the preferable technologies would be those involving the least risk. Technologies which people can understand and control are preferable; this is the basis for the "hard path" vs. the "soft path" options.

High technology often serves to create monopolies, discouraging the diversity that tends to optimize solutions and, because of the size of the investment, becomes self-perpetuating. High technology products do not respond to needs, they define needs, which explains why "standard size" nuclear electrical plants are 1,000Mw. Economics has shown that smaller, perhaps more appropriately-sized plants should not be constructed. The scale precludes use of renewable resources, like biomass, to fuel such a monster. For example, a 1,000Mw plant working at a load capacity of 80 percent and an efficiency of 33 percent requires about 72 trillion Btu for fuel. Some 4,500 square miles of forest (about the area of Connecticut) would be required, each year, to provide that much fuel.

The hard path relies on expansion of centralized technologies such as large power stations; the soft path develops renewable resources in

a smaller, less demanding scale. Some feel that the paths are mutually exclusive. Choice of path will influence the future structure of society. Soft energy paths:

a. Depend on renewable energy flows such as the wind, vegetation and the sun.
b. Are diverse, so that energy supply comes from a variety of small sources tailored to local needs.
c. Are easy to understand and use.
d. Are matched in scale and distribution--windmills are used where there is steady and abundant wind; methane is used where digestible products are abundant.
e. Are matched in quality to end-use. Using high grade energy (like electricity) to heat water is inefficient. A power station must use three units of fuel to get one unit of electricity; the rest is lost to the environment as heat.

The goal of energy education is <u>not</u> to train people to turn off the lights. Energy literates will recognize the error of wasting needed resources and turn off the lights for their own and future good. Paternalistic communication of "good" may train people to be dependent on others' judgment, but it certainly does not educate them. Energy education provides the opportunity to use knowledge and decision-making skills to foster the personal and social development of humans <u>within</u> interdependent natural and social systems.

By helping students examine the choices between the hard path and the soft path, we can pose a major ethical question: Should future generations be burdened with the excesses of the present generation? Teaching people to live on our <u>energy income</u> rather than continue to deplete our <u>energy capital</u> will begin to prepare people to make realistic energy decisions.

12

SOLAR TECHNOLOGY: AN OVERVIEW

The idea of harnessing solar radiation for direct use by humans is not new. Xenophon, a Greek writer, described solar architecture in 400 B.C., and legend claims Archimedes won a naval battle with a solar weapon in 212 B.C. The sun is the ideal energy source, one that is abundant and non-polluting. But there are some problems. Although solar resources are abundant, they are diffuse and require large areas to gather enough energy to be useful. Solar energy collectors cost money--for raw materials, to build, to install and to maintain. Another problem is that sunshine is intermittent. The number of sunlight hours and availabilty of solar resources fluctuate depending on variables like weather, season and location, and phasing energy needs to match available solar is difficult.

This technology overview is neither extensive nor complete, and it does not all apply to Florida. It is intended to provide a thumbnail sketch of where we are and where we may be going with a sola future Persons interested in more details should refer to the bibliography.

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SOLAR HEATING AND COOLING:

Solar heating and cooling are areas where applied solar technology is making a significant impact on energy consumption. This is especially true of solar water and space heating. Two distinct but complementary styles are used to convert sunlight to thermal energy: (1) Active

systems generally use mechanical power like pumps or fans to collect, store and distribute energy, and (2) Passive systems use natural energy flows produced by conduction, convection and radiation to store and transport thermal energy within a structure. Designs frequently combine both types of systems, resulting in a hybrid system. Adequate insulation is one of the most cost-effective ways to save energy in a new or used home, and it is vital for any house that incorporates a solar system.

Passive systems are generally part of the overall design of a structure and can be the most cost-effective, natural way to provide part of your heating and cooling needs. Passive systems are usually characterized by the use of abundant heavy building materials such as concrete, brick and water. The approaches to passive design fit five basic groups:

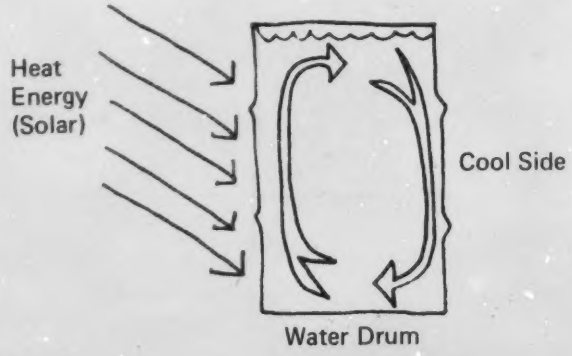
1. Direct Gain Systems--Such systems incorporate south-facing windows (often called solar windows) to admit sunlight into the living space. When the sunlight strikes interior surfaces of the building it changes from shortwave light energy to longwave heat (radiant) energy. This radiant energy, which does not readily pass through glass, is "trapped" in the building's walls, floors and ceilings (thermal mass) and is available for use later (at night) when heat is needed to maintain comfort. Excessive heat gains during the day, and losses at night or on cloudy days, are often controlled by movable window insulation or "thermal drapes."

2. Thermal Storage Wall--Thermal storage walls operate on the same principles as do direct gain systems except that the massive storage material is placed between the solar windows and the living space. Thus, sunlight does not enter the living space of the building directly; instead, heat energy enters the living space by traveling through the thermal storage wall. For this reason, thermal storage walls sometimes are called "indirect gain" systems. Two widely used thermal storage walls are the "Trombe wall" and the "water wall."

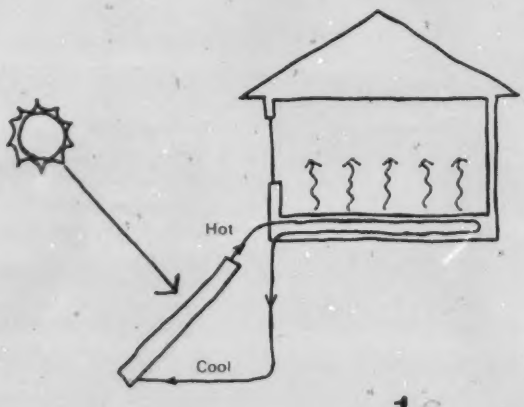
3. Sun Spaces--Sun spaces are similar to the thermal storage wall, the major difference being that the distance between the solar windows and the storage wall is increased to allow the interim space to be usable either as a greenhouse, atrium, entry foyer, sun room, or simply as a buffer zone. When used as a greenhouse, the sun space can provide valuable humidity, oxygen, food and plants to the home occupants.

4. Roof Ponds--A roof pond also resembles a thermal storage wall. The storage medium, however is horizontal (in the roof) rather than vertical and is liquid rather than solid. Water is stored in containers and is warmed by the sun during sunny periods and insulated at night and on cloudy days with movable roof insulation. For cooling, the pond is used in reverse, with the insulation being used during sunny periods and removed during cool night periods.

5. Convective Loop--The convective loop is based on the natural thermodynamic tendencies of fluids (either liquid or gas). When a fluid is heated it tends to rise, leaving behind a void or low-pressure zone, and other, cooler fluids rush in to fill that space. Thus, if a container of fluid (a house filled with air or a drum filled with water) is heated on one side only (solar windows occur only on the south side of a building) the fluid will tend to circulate.



The heat which is generated at one area of the container is transferred to another area (usually the highest point in the container). In solar heating, this principle results in what is commonly called the thermosiphon system, where a storage medium is located higher than the collector or solar window, allowing natural convection to move and transfer the thermal energy from the collector to the storage medium.



Active solar systems generally use a collector with an absorber plate that transfers the sun's heat to a working fluid (either liquid or air) and a translucent cover plate that prevents reradiation of heat to the environment. Insulation at the back of the collector also reduces energy losses. Storage is required if the thermal energy collected during sunlight hours is to be used at night and when the sky is overcast. Water is usually used as the storage medium for liquid systems and rock beds store heat for air systems. Cooling is handled by absorption chillers similar to those in gas refrigerators. The economics of solar cooling devices generally are not competitive except in commercial sizes. Higher working temperatures need more expensive components than those required for space heating.

The economics of solar heating and cooling should be considered by using the value of the energy saved over the life of the system. Purchasing a solar heating system is not unlike paying all your heating bills for the next several years at one time. Because of solar's relatively high initial cost, life cycle costing is useful in determining the projected costs when comparing solar with conventional systems. Life cycle costing is a measure of what something will cost totally, not only to buy but also to operate over its lifespan.

Solar energy is technology-feasible and economically viable for heating domestic hot water and swimming pools. Where electric rates are high and winters are harsh, solar space heating is economically attractive. All the active, passive and hybrid systems hold high promise for the future when conventional fossil fuel pricing and availability are considered.

SOLAR ELECTRICITY:

Solar electricity technologies include solar thermal energy conversion and photovoltaics (solar cells). Solar thermal conversion uses specially designed solar collectors to generate steam, which drives a turbine and generator to produce electricity. Only the solar heating of the boiler distinguishes this electrical system from that of a fossil-fueled electric plant. Because existing power-generating technology can be used, solar thermal power systems are being studied for many commercial applications. Solar cells convert sunlight directly to electricity.

Solar Thermal Conversion Systems--The power tower or central receiver system has a large tower surrounded by a field of sun-tracking mirrors (heliostats) which concentrate the sun's rays onto a boiler located in the top of the tower. A 10,000-kilowatt plant of this type under construction in Barstow, California, has a 4.75-acre field of heliostats. Another system uses a field of sun-tracking parabolic troughs to concentrate the sun's rays onto a thermal fluid at the focus of the parabola. The fluid moves to a receiver, where it produces steam to drive a turbine and generator.

Photovoltaic Systems--Conventional collectors convert solar radiation to heat; photovoltaic cells convert sunlight directly to electricity. This simple solid-state device holds the promise of a long operating life with little need for servicing. Since electricity is our most convenient form of energy, solar cells could be used for a wide variety of electrical applications.

18

Solar cells are interconnected and are usually placed into sealed units called modules. Any number of these modules, each of which might deliver 12 watts, are then put into frames or arrays designed to meet specific electrical demands. Since solar cells only produce power only during daylight hours, they require a storage system or backup system if power is needed on cloudy days or at night. Photovoltaics are finding widespread applications for roadside telephones, forest fire stations and other remote situations where conventional utility lines do not reach.

The technology of photovoltaic conversion is well developed, but large-scale application is hampered by the high price of solar cells. Recently the manufacturing process has been significantly improved, and the current goal is to reduce costs enough to make solar cells competitive with conventional electrical sources by the mid-1980s.

Other solar electric technologies currently being studied include ocean thermal energy conversion (OTEC), where minor differences in ocean temperatures might be used to convert a low boiling point liquid to a gas to drive turbines. The solar power satellite (SPS) would use a combination of microwaves and photovoltaics to produce electrical energy. These high technology approaches are beyond detailed description in this overview.

WIND ENERGY:

Wind energy is produced when solar radiation is converted into kinetic energy by the differential heating of the earth's atmosphere. A windmill or wind turbine converts the kinetic energy of moving air into mechanical motion. Wind-produced mechnical energy has long served

people by providing power for transportation at sea and for many agricultural purposes. Estimates of available wind energy vary, but even the lowest estimate represents a substantial energy potential.

Wind power has been extensively used in the United States. Before rural electrification occurred, more than six million small windmills generated household and farm electricity and pumped water; only 150,000 are still in use. The largest wind machine built in the United States had a rotor diameter of 174 feet and generated 1250 kilowatts of electricity. It operated from 1941 to 1943, when the Vermont project was abandoned.

Modern plans to use wind power cover a wide range of sizes and technologies. Some new machines have blade spans larger than the wing span of a jumbo jet and weigh many tons. Components of fiberglass, steel, aluminum, plastics and other materials are used.

The construction of wind generators does not require any new technologies, and cost estimates in favorable regions are close to those of other energy sources. Unfortunately, to produce appreciable amounts of power, installations have to be large and are costly. Wind, like the sunshine that produces it, is a variable resource. Wind velocities decrease considerably at night and vary with the weather. For wind power, the problem of storing energy must be solved.

BIOMASS:

Biomass is any material derived from growing organisms--such as wood, corncobs, seaweed or, indirectly, from garbage. Biomass is a natural form of solar energy and is produced by a natural process, photosynthesis, as long as the sun shines. It has been people's form

of fuel for most of human existence. Wood provided 75 percent of this nation's energy just a hundred years ago--a quantity equal to about 3 percent of our current inflated energy appetite. Sweden now gets 8 percent of its total energy demand from wood, and Finland uses wood for over 17 percent of its energy needs. The United States might well return to using biomass to provide part of its energy needs.

In many cases, residues from agriculture, forestry operations and municipal wastes form a near-term source of solar energy which can be collected and used now. Such residues might provide up to 5 percent of the nation's energy by 1985. The Florida Resource Recovery Council estimates the energy potential of Florida's solid wastes at 7 to 10 percent of the state's electrical demand. When environmental costs and benefits are fitted into the resource recovery equation, the energy recovered represents only a small part of the savings.

Conversion of biomass to liquid, solid or gaseous fuels is an area of considerable interest. Since people have been using biomass for thousands of years, many conversion methods have been developed. In rural America, many people are using woodburning stoves for space heating, water heating and cooking. Wood now provides Americans with half as much energy as does nuclear power. Between 1972 and 1977, the number of woodburning stoves increased from 250,000 to two million. One-fifth of the homes in northern New England now rely on wood as their primary energy source, and an additional 30 percent use it as a supplemental source.

Pyrolysis is the high-temperature heating of biomass in the absence of oxygen that produces a dark liquid which can replace petroleum for many industrial uses. Biomass is attractive for making alchohol fuels.

Methanol, is derived from wood or municipal wastes, and ethanol comes from various grains and other agricultural products. In many ways, alcohols are superior to gasoline as a fuel; they increase octane and they can burn cleaner than gasoline. Mixtures of alcohol and gasoline produce the composite fuel "gasohol," which is commercially available in several states. Using agricultural wastes to produce gasohol for local markets appears to be a reasonable application of solar energy, but because American agriculture is so energy-intensive, gasohol's contribution will be limited.

Gasifiers are being developed to generate low-energy methane gas (swamp gas) from organic materials. Methane gas can be compressed and substituted for natural gas and oil in existing equipment. Digesters that convert animal manure to pipeline-quality gas are already operating on a commercial scale, and the by-products from these digesters can be used as animal feed or fertilizer. Methane production from waste products appears to be a very important source of energy.

Over-harvesting forests has created many deserts in the world; our greed for cropland helped produce the Dust Bowl of the 1930s. Mining land and water for energy could ultimately destroy the productivity of the earth. Biomass has the potential of being an ecologically attractive form of energy if sufficient care is taken to preserve the integrity and productivity of biological communities.

Solar Energy in Florida

present and future prospects

by Gerard G. Ventre
and Subrato Chandra
Florida Solar Energy Center
EN-1 First Printing, November 1979
Second Printing, February 1980

Why Solar?

Florida, the "Sunshine State," has abundant solar energy and a significant population to utilize it. The only region of the U.S. that has more sunshine is the desert southwest, which is much less populated and, consequently, has much less demand for energy.

Florida does not have significant fossil fuel resources and is located far from the coal producing states. Ninety percent of Florida's energy is derived from fossil fuels and almost all of its energy is imported.

Fossil fuels are becoming scarce; world oil production will most likely peak between 1985 and 2000. U.S. oil production peaked in 1970.

Fossil fuel has environmental problems—not only the buildup of various pollutants, but also the large-scale production of carbon dioxide, which may seriously affect the world's climate.

Florida's economy is vulnerable to fossil fuel supply interruptions, and it therefore behooves us to develop our valuable energy resource—sunshine.

Benefits of Solar

Solar is a renewable, clean energy that is in abundant supply.

Unlike petroleum, the price and availability of solar energy are not subject to manipulations by other nations.

A healthy solar industry will aid in Florida's industrial development.

Solar applications are labor-intensive and will create jobs.

Solar energy represents a decentralized power source that adapts to a variety of appropriate applications, ranging from heating water to generating electricity.

Solar energy has strong public appeal.

Sunshine is the most important reason for Florida's healthy tourist industry.

The sun is the source of all life on earth.

Solar Water Heating

Water heating represents the state's oldest use of solar energy; South Florida has had solar water heaters since 1900. It is estimated that about 30,000 to 50,000 units were installed by 1950, but about that time their popularity began to decline due to readily available cheap energy from fossil fuels.

Solar water heaters are simple, commercially available, and economically competitive with electric water heaters.

Water heating accounts for about 25 percent of residential energy use in Florida, or roughly 6 percent of Florida's total energy use.

Solar systems presently cost between $1,000-$3,000 (about $1,500 average statewide) for a family of four and may save as much as $150-$200/year in electric bills. They cost $500-$1,000 for do-it-yourselfers.

Because they are material-intensive, the prices of solar water heaters are not expected to come down as they did for electronic calculators. Consequently, the sooner a person buys a solar water heater, the sooner he begins to save.

Solar Water Heating cont'd.

Federal income tax credits of 30 percent of the system cost for the first $2,000 and 20 percent for the next $8,000 are available. For a $1,500 solar water heater, the net cost to the consumer is only $1,050.

Florida now exempts solar systems from the 4 percent sales tax.

The size of Florida's solar water heating industry is represented by the following statistics:

—An estimated $10 million in 1979 sales.
—About 75 manufacturers and over 500 vendors in the state.
—About 7,000 units installed in 1979. Total number of new installations since 1973 is estimated at about 22,000.

Projections/Goals: "2 million by 2000!"

	Estimated No. of Units	
	1985	2000
Florida (hot water only)	**300,000**	**2,000,000**
U.S. (includes space heating)	**2,500,000**	**—**
California (includes space heating)	**1,500,000**	**—**

Standards on solar collectors exist, and the industry is voluntarily meeting them.

FSEC tests and certifies collectors for consumer protection and is currently preparing mandatory system standards for the future.

Solar Pool Heating

Solar pool heating is not only currently available, it also is the most economically attractive solar technology.

A large market potential exists in Florida, due to the great number of pools and the steadily growing population to enjoy them.

Individual savings by substituting solar heat for fossil fuels in heating a swimming pool are significant.

Pool heating is a major solar industry. The square footage production of low-temperature pool collectors has exceeded that of all other kinds combined (primarily because considerably larger collector areas are required for pool heating).

Typical residential costs are about $2,500 if commercially built and installed, and as low as $500 if done by do-it-yourselfers. Solar pool heaters typically extend the swimming season three to four months beyond the normal season in Florida.

The estimated size of Florida's solar pool industry: 3,500 installations in 1979, with total sales of $5 to $9 million.

Solar Space Heating and Cooling

Space heating accounts for only about 9-10 percent of residential energy use in Florida due to our warm climate.

Therefore, active space heating systems are economically unattractive in most of Florida. Exceptions: Do-it-yourself systems may be economical in northern Florida.

Space cooling accounts for about 33 percent of residential energy use in Florida.

It behooves us to develop solar cooling because the sun shines most brightly (i.e., the solar resource is most available) when the air conditioning is most needed.

However, solar thermal cooling (absorption, Rankine, or desiccant cycles) is economically unattractive today. Present cost is about $30,000 installed for a typical residential absorption system. Future prospects may improve if significant cost-reducing breakthroughs are made. Commercial applications appear more promising.

Solar cooling by photovoltaic cells generating electricity and driving conventional air conditioners may become attractive in the future if photovoltaic prices come down as projected.

Passive solar cooling techniques that work well in a hot, humid climate such as Florida's need to be developed. (The word "passive" implies natural use of the solar environment to achieve the comfort levels desired. Very little or no mechanical equipment is required with passive designs.)

Passive heating is technically feasible in Florida, but further analyses are required to evaluate its cost effectiveness.

Passive heating and cooling in Florida are more closely associated with energy-efficient building design rather than with what are commonly referred to as the "passive solar technologies." However, additional research in passive solar heating and cooling should be vigorously pursued.

Solar Cells/Photovoltaics

Photovoltaic or solar cells are very attractive, as they generate electricity directly from the sun without any moving parts or noise. Therefore, many energy end-uses can be provided, ranging from household lighting to utility electricity generation.

Their technical feasibility/reliability has been proven through the space program's use of cells to power satellites.

The major barrier is cost. At present, photovoltaics are competitive only in remote applications such as water pumping for irrigation, communications relay stations, cathodic (corrosion) protection of bridges, etc.

Unlike solar thermal collectors (like those used for water heating), large reductions in cell costs are expected in the future. Department of Energy R&D already has reduced cell costs from $200/peak watt to $7-15/peak watt. A major DOE R&D effort is underway.

1986 cost projections by DOE for residential applications (in 1980 dollars):

Array Cost ($/peak watt)	**$0.70**
System Cost ($/peak watt)	**$1.60**
Equivalent electricity cost in Florida	**7¢/kwh**

Note: Peak watts refer to electric power produced when the sun is brightest.

The national goal is to have 500 MW of photovoltaic electric generating capacity by 1990.

Florida photovoltaic research includes applications engineering at the Florida Solar Energy Center and basic cell research at the University of Florida.

24

Energy from Biomass

Biomass resources include all organic matter except the fossil fuels.

Examples of biomass resources include urban refuse, manure, logging and wood production, forestry residues, crop residues, industrial wastes, municipal sewage sludge, special energy crops, and aquatic energy farms.

Biomass energy conversion techniques include direct combustion, thermo-chemical gasification and liquefaction, anaerobic digestion for methane production, sugar fermentation to produce alcohol, and hydrogen production.

There is a relative abundance of useable land in the U.S., particularly in Florida.

Environmentally, organic wastes are typically low in sulfur, and the production of ash in combustion is much less a problem than with coal. Nitrous oxides will be produced, as always, when combustion occurs in air.

Water hyacinths can be used to generate methane gas. This process currently is not cost-effective, but when it becomes so it will also help free Florida's waterways for both navigation and recreation.

Biomass fuels (or biofuels) presently contribute approximately 1 to 2 percent of our (U.S.) energy needs, mostly as direct combustion of wood.

Because of climate and terrain, Florida is exceptionally well suited to develop biomass resources. The combination of rainfall and long growing seasons, which allows for multi-crop production, makes Florida a leader in terms of biomass resource potential.

Solar Industrial Process Heat

The industrial sector is the largest user of energy in the U.S., accounting for approximately 41 percent of the total national energy consumption. However, only 16 percent of Florida's total energy use is for industry.

Production of process heat and steam accounts for approximately two-thirds of the total energy used by the industry.

There is significant potential for the use of solar energy to provide process heat and steam and, therefore, to make a significant contribution to the nation's energy needs.

Not only is Florida in an extremely vulnerable position in terms of available fossil fuels, its economy is heavily dependent upon tourism, which could be severely affected by liquid fuel shortages. These same fuel shortages could accelerate the migration of northerners to the attractive warmer climates of Florida. Consequently, there would be a need for both jobs and a more stable economic base. Solar industrial process heat could provide Florida with more manufacturing capability (i.e., more industry), more jobs, and a stronger economy.

An industry that is partially fueled by solar energy would be environmentally more acceptable than the heavily fossil-dependent industries that have developed over the last century in other parts of the country.

There are possible applications of solar industrial process heat to Florida's citrus and paper industries, whose relatively low temperature requirements could easily be met by energy from the sun.

Agricultural Applications of Solar Energy

Agriculture is the world's greatest user of solar energy for human needs, with about 11 percent of the land area under permanent crops.

Agricultural applications of solar energy include heating and cooling of greenhouses, food processing, grain drying, crop drying, and heating of livestock shelters.

The temperatures required for many agricultural processes are relatively low.

The basic technology already exists for collecting the required heat from the sun.

Most agricultural applications have intermittent heat requirements (i.e., the requirements vary with the weather and the planting, growing, and harvesting seasons). Because of limited seasonal use, the solar systems must be set low in cost to be economically attractive.

Presently, the major agricultural application of solar energy in Florida has been for greenhouse heating.

Like other applications, solar energy for agriculture will become more attractive as the cost of conventional fuels continues to escalate.

Other Solar Applications

There are other solar technologies and applications that either are not particularly suited for Florida or will not be available until well into the future. These technologies include wind power, solar thermal electric conversion, ocean thermal energy conversion, and solar power satellites.

Wind power systems will become increasingly attractive in those locations of the country where the amount and quality of the wind energy make them economically viable. The potential for wind generated electricity is significant on a national scale, but there is limited potential in Florida, mainly along the coastline or possibly offshore.

Solar thermal electric conversion technologies can be categorized as central receiver plants, distributed collector systems, or total energy systems. Most of these systems use high-temperature concentrating collectors which must track the sun (and are consequently quite expensive). Because of their dependence on a large ratio of direct sunlight to diffuse sunlight, these systems at present do not appear particularly attractive for Florida.

Ocean thermal energy conversion (OTEC) could derive significant energy from the Gulf of Mexico, off the Keys, and in the Florida Straits; however, serious technological and economic problems must be alleviated if this futuristic alternative is ever to become a significant supplier of our nation'a energy.

Solar power satellites (SPS) possess features which are particularly attractive for longer-term energy supply. The interface of this program with NASA Kennedy Space Center activities is of special interest to Floridians. Although the size (on the order of 25 to 50 square miles per satellite), cost and complexities of this program are enormous, its contributions beyond the year 2000 could be very significant.

Conclusions

Although the contribution of solar water and pool heaters in displacing fossil fuels is small, the application of these technologies should be strongly pursued for the following reasons:

- —They represent a Florida industry which encompasses approximately 75 manufacturers and over 500 vendors.
- —The installation of solar equipment is labor-intensive.
- —The manufacturing of solar equipment is a new and environmentally clean industry.
- —Domestic water and pool heating (and some agricultural uses) are presently the only cost-effective solar technologies which are applicable to Florida's energy needs.
- —The success of these near-term technologies should influence the rate and manner in which other solar technologies are introduced.
- —The public awareness and acceptance of near-term solar technologies may have a positive influence on the public's attitudes and practices concerning energy conservation. A solar water heater allows direct citizen contact with and utilization of energy-conserving equipment while providing a needed commodity (hot water) and an immediate savings on monthly energy bills.
- —The development of widespread solar industry involves the solution of a variety of institutional problems that will pave the way for a more rapid introduction of the future solar technologies (i.e., problems and conflicts associated with financing, inspecting, regulating, and protecting the consumer).

In 1979, the U.S. spent over $60 billion on oil imports alone. The 1979 federal budget for solar development was less than a billion dollars.

Florida (which is both populous and heavily dependent upon energy-intensive tourism) is blessed with abundant sunshine. Florida should vigorously pursue the development of solar energy technologies offering the greatest benefits to Floridians. Those to which we should make our most serious commitment include:

1. Domestic water and pool heating.
2. Photovoltaics (including photovoltaic cooling).
3. Energy from biomass.
4. Passive cooling, illumination and heating.
5. Industrial process heat.
6. Agricultural applications.

In the longer term, ocean thermal energy conversion and solar power satellites may be important to Floridians.

Current Uses of Energy by Sector in Florida and the U.S.

Sector	Florida	U.S.
Transportation	**38%**	**26%**
Residential	**23%**	**19%**
Commercial	**16%**	**14%**
Industrial	**16%**	**41%**
Other	**7%**	**—**

SUN DAY SUGGESTIONS FOR SCHOOLS*

* Ask the principal to declare Sun Day in the school as a special day devoted to solar energy studies, special programs, games, contests, presentations and exhibits.

* Survey the school library's energy books. Request the librarian to add books on energy conservation and solar power. Ask that these materials be put on display.

* Organize an energy information center at the school and have an open house for the community on Sun Day and other days. Research careers in solar energy and provide job information.

* Perform solar energy experiments in science classes using class-constructed materials.

* Construct solar collectors, window box heaters, cookers, stoves, etc. in shop classes. Design solar structures in drafting/architecture classes.

* Debate the different energy sources in speech and drama classes for the school or a town meeting energy conference. Help prepare radio and television public service announcements advertising solar (and Sun Day) events in the area.

* Create and prepare skits or plays on wind and solar energy in drama classes to present to other students, parents and community groups.

* Stage brief "hands-on" sessions for driver's education students on engine tune-ups, maintenance and gas-saving techniques. Organize car pools for students who drive to school and/or for commuters within the community. Offer car maintenance seminars for the community.

* Calculate the comparative costs of different energy strategies (solar, oil, nuclear, conservation) in math classes.

* Study energy conservation and farming methods using renewable energy sources in agriculture, ecology and biology classes. Build solar greenhouses, crop and fruit dryers, etc.

* Examine the development and cultural differences of energy use in history classes. Investigate the principles of energy use and conservation in early American architecture. For an international perspective, try to correlate energy demands in other cultures with the availability of energy resources.

* Write essays, poems, haikus, skits, songs and research papers about solar energy in English classes. Read myths and legends about the sun. Study how the sun has been used as a symbol in literature and art.

* Study solar energy use in other cultures and countries in language classes. Translate energy vocabulary into different languages.

* Design sun-theme art projects in arts and crafts classes: banners, buttons, murals, pillows, mobiles, stationery, collages, kites, puppets...

* Start an energy section in the school newspaper. Work with local newspapers, radio, etc. to make sure local Sun Day events are covered.

* Write or call the state energy/consumer office and report to the class about their energy programs. Do they provide consumer information on solar energy? consumer protection programs? energy education programs?

* Write letters to members of Congress and the President encou-

raging them to support solar energy. Inquire about your state's solar legislation and investigate what legislation has been passed in other states.

* Develop an energy presentation for the community that includes displays, shows, speeches, art work. Identify buildings in the community that waste energy, and offer possible conservation programs as solutions. Investigate building codes to see if solar energy is being encouraged or discouraged. If the latter, then consider possible changes.

* Set up a speakers bureau of solar energy experts.

* Stage a contest for designing Sun Day posters, songs, T-shirts. Think of other art projects. Make a sundial for the school.

* Design bulletin board displays concerning the sun and solar energy issues. Continually update the displays with "Energy Facts of the Week" brought in by different students.

* Conduct an energy audit of school buildings. Find out how energy can be conserved.

* Distribute an energy conservation checklist with energy-saving ideas for the home, and encourage students to work with their parents to make their homes energy efficient. Help install insulation, weatherstripping.

* Build solar cookers and prepare a group luncheon. Sponsor a solar cooking contest.

* Sponsor a festival of solar energy films and slideshows.

* Make field trips to solar buildings in the area. Photograph them, then organize a photo exhibit or produce a slideshow.

* Build a solar greenhouse for the school or community. Or visit a local greenhouse. Consider the different methods of greenhouse construction.

* Make a science fair project on solar energy. If enough students are interested, stage a solar energy science fair including wind, water and biomass projects.

* Investigate local banks to find out what homeowner loans they offer for solar investment.

* Make maps of the U.S. or regional areas depicting the amount of sunshine received (data is available at weather stations). Record the number of sunny days a year.

* Ride a bicycle or walk as often as possible to conserve fuel.

* Write a book about the sun, either as a class project with each student adding onto the story, or as an individual assignment.

*FROM: Center For Renewable Resources

SUNSHINE QUICKIES*

Use the "Quickies" whenever you have a few extra minutes. Most are designed to promote divergent thinking and are unstructured, so provide as few directions as possible. A few require materials, be certain you have the supplies needed before the assignments are distributed. Cut them out of this book and give them to small groups of students. Then get out of the way!!!

Enersun: The energy of the sun can be used indirectly.
Action: Show how the sun's energy affects people through:
1. plants
2. soil
3. air
4. water

More: Show how people use indirect solar energy.

Enersun: Living things are interdependent with their environment.
Action: Listen to the John Denver record, "Sunshine," and consider how sun has affected our modern culture.
More: Locate other examples of "sun" in our culture. Find brand names that use "sun" in them. Write another verse to the song "Sunshine." Make a picture collage of how sunshine makes you feel.

Enersun: The sun supplies most of the earth's energy.
Action: List the direct and indirect uses of solar energy by humans.
More: Draw a picture showing you using solar energy in 20 years.

Enersun: Most energy comes from the sun.
Action: Show that we get energy from the sun: in the classroom
outdoors
More: Show ways man uses heat from the sun. Show ways man reduces heat from the sun.

Enersun: The energy of the sun can be used directly.

Action: Describe examples of solar heating: By nature and by people.

More: Use some artform to describe how some animals use solar heating in reproduction. Write a solar energy bill of rights.

Enersun: Green plants use the sun's energy to make food and store it.

Action: Set up a demonstration to show that green plants use solar energy to make food.

More: Find a way of helping green plants make and store energy. Grow a green plant in the dark.

Enersun: The sun provides light energy.

Action: Find a ray of sunlight coming through a crack or hole. Watch it change. Feel it.

More: Draw a picture of what life would be like inside a sunlight ray.

Enersun: Plants store solar energy.

Action: Find the ways plants store energy. Find the places in which plants store energy.

More: Find a plant that does not store energy. Find other energy storage places.

Enersun: Energy can be changed.

Action: Go outside and find energy changing. Draw a picture of the energy being used. Invent a way for the sun's energy to do work.

More: Identify a process which puts energy into useful work.

Enersun: Energy is used to supply the needs of (people) living things.

Action: Finish this sentence: "I can enjoy the sun's energy by..."

More: Draw a picture to show how you enjoy the sun's energy.

Enersun: Do something! People use energy to do things.
Action: Use the sun's energy to do something.
More: Do the same thing another way.

Enersun: Use solar energy to make sunshine tea.
Action: Use one tea bag per 1.5 cups of water, and 1 teaspoon of honey per tea bag. Add the honey to the jar first. Fill the water, add tea bags and place in the sun 4-6 hours.
More: Enjoy your tea while calculating how much energy you saved.

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*FROM: Lee County Energy Education Project, Ft. Myers, Florida

SUN SEARCH

Teacher's Note: Some students need ideas to nudge them into projects. Sun Search is a springboard for students wishing to do library research about solar energy. Of course, the results of their projects will be shared with the entire class!!!

SOLAR FOLKS

1. The mean daily solar radiation is measured in Langleys. This is a direct measure of the amount of solar energy received at a given location. Langleys were named for Samuel Langley, a pioneer in aeronautics and solar energy. What can you find out about Mr. Langley?

2. The reign of Louis XIV of France (1643-1715) was an era of solar experiments. Louis gained the title of Sun-King. Why?

3. Archimedes saved the Greek city of Syracuse from Marcellus and his Roman fleet by using reflectors to concentrate solar energy on invading ships. The fleet caught fire and burned. During the siege of Constantinople, another Greek, Proclus, remembered history and burned another enemy fleet. Is there any credibility to these stories?

4. In 1695, Georges Buffon proved the potential of concentrating solar energy by igniting wood at 200 feet, and melting lead at 130 feet. He used a parabolic-shaped mirror. How are these mirrors used today?

5. Antoine Lavoisier (1743-1794) built a solar furnace with curved glass sections filled with wine. The furnace was used to melt platinum at about 2,000°C. How are solar furnaces being used today?

SOLAR THINGS

6. There is more relative energy in the ultraviolet range of the light wave. It "strikes harder." Compared to other forms of light energy, ultraviolet is a steel ball, visible light is a golf ball, and infrared is a rubber ball. What is being done to capture this ultraviolet energy?

7. Our sun has surface temperatures of 10,000°F and interior temperatures of 20 million degrees Fahrenheit. The diameter is 864,000 miles, and its mass is 330,000 greater than the earth's. How does it compare with other stars?

8. The radiation that reaches earth is 9 percent ultraviolet, 41 percent visible, and 50 percent infrared. The total radiation absorbed by the earth is 1.73×10^{17} watts, or 232 trillion horsepower. Devise an energy budget that uses 1 percent of this power.

9. The mean value of the solar constant is 1.395 killowatts per square meter of the earth's surface. If all this energy was collected, how much land would be needed to provide enough electrical energy for your city or home?

10. In the 1900s, Eastern Sun Power Company of Cairo, Egypt, built the world's largest solar power plant. It produced 50 to 100 horsepower but was abandoned during World War I when fuel-fired systems became available. What kinds of solar power plants are being developed today?

11. The solar energy reaching the earth is but one thousand-millionth of the sun's total output, yet this is 2,000 times the requirements of Americans. The yearly solar radiation received in the U.S. is 9,000 trillion kilowatts, the equivalent of 1,200 billion tons of coal. What steps are being taken to use this renewable resource?

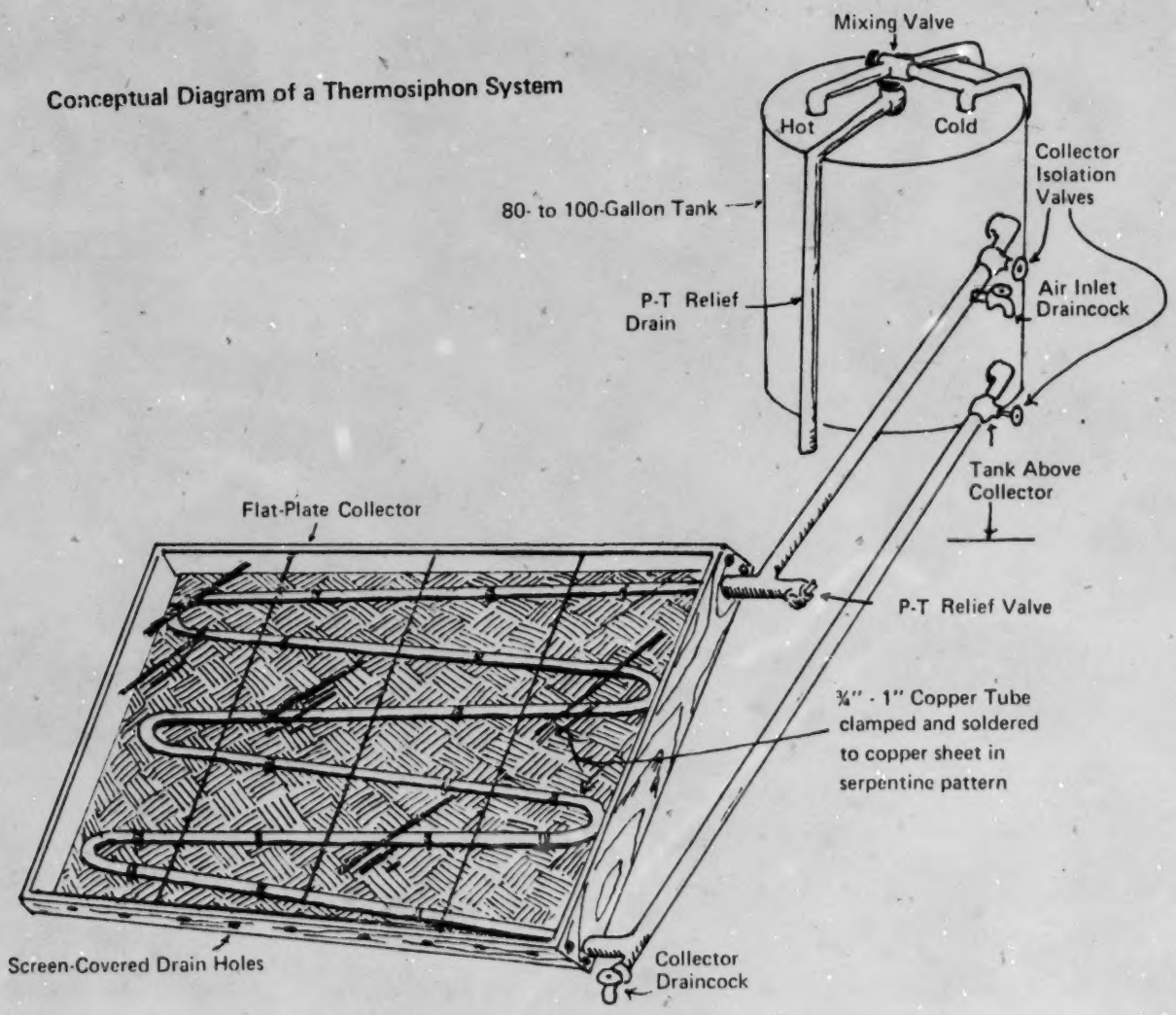
12. About 30 percent of the sun's energy that strikes the earth's atmosphere is immediately bounced back into space. The atmosphere, land masses, and the oceans absorb 45 percent in the form of heat. Almost 23 percent operates the water cycle, and about 1 percent is used in air and ocean circulation. Less than 1 percent is used by plants. How many kilowatts are left? Is that enough to power the globe?

13. In 1880 a solar-powered press was working in France. What happened to it?

STUDENT PROJECTS

If I hear, I forget;
If I see, I remember;
If i do, I understand.

Conceptual Diagram of a Thermosiphon System



A BACKYARD SOLAR WATER HEATER

By

Stu Gleman

The basic idea here is that solar is people-scaled technology. Let's start with solar hot water:

Solar domestic hot water systems were popular in Florida at one time, when money was scarce and electricity was expensive. The systems were of the "old reliable" thermosiphon variety. (You build a flat box, see, and put some pipes in it. Paint it black and put glass on top. It is placed lower than the water tank, and don't cross the pipes. Whatever you do don't forget to drain it before it freezes.) Strange to say, these unsophisticated, low-technology systems worked well enough for most people.

If you are interested in making your own, here are two rules-of-thumb for low-technology, backyard solar systems:

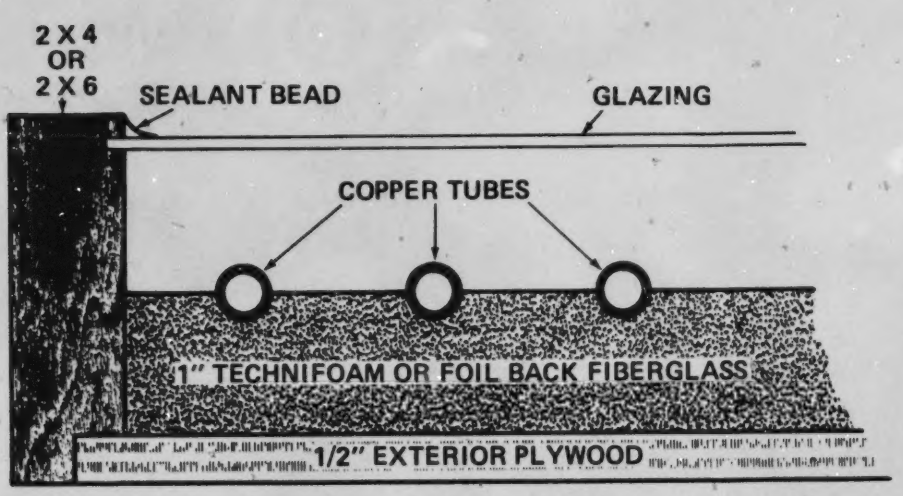
- o Use 10 to 12 square feet of collector for each member of the family.
- o Use two gallons of storage for each square foot of collector.

Thus, a four-person family would need 40 square feet of collector and an 80- or 82-gallon storage tank.

I recommend two excellent publications giving detailed design and construction information on conventional Florida-type solar collectors and systems:

---- Build your Own Solar Heater, published by the Environmental Information Center of the Florida Conservation Foundation, 935 Orange Avenue, Winter Park, Florida (Telephone 305/644-5377).

---- Solar Domestic Water Heater, by C. D. Baird, of the University of Florida, IFAS, University of Florida, Gainesville, Florida 32611.



CROSS SECTIONAL VIEW

This illustration shows the basic design of a somewhat unconventional solar collector, which is more easily constructed than most flat-plate designs.

Notice that the "absorber plate" is conspicuous by its absence! The copper pipes are pressed against the foil backing of the insulation until an indentation is formed. They are kept securely in position by the cross braces. The entire surface, pipes and insulation, is painted with flat black paint.

Let the actual size of the collector be determined by the size of the glazing you obtain.

It is recommended that the collector be assembled, painted and glazed but not sealed. Leave it in the sun for a few days, until all solvents and vapors are baked out of the paint. Likely, you will see a haze on the inside of the glass (this is called "outgassing", and is violently deplored by the folk who test collectors). Remove the glass, clean it, replace it, and finally seal the collector/glass joint.

RECOMMENDED MATERIALS (These represent my opinions, and may be true):

BOX:

Sides--2" x 4" pressure treated lumber or non-resinous wood, such as cypress or redwood. Back--1/2" exterior or marine-grade plywood.

GLAZING:

1/8" tempered glass. (Obtain from glazing supply as "patio door seconds," for example). If you can't get tempered glass, get double-strength window glass, but remember that it breaks easier, and into bigger, sharper pieces. (If you really wish to be safety-conscious, consider the use of fiberglass-reinforced plastic for glazing. Two possibilities: Kalwall Corporations's "Sunlite Premium II" or Vistron Corporation's "Filon.")

INSULATION:

Celotex "Technifoam" 1 inch thick. Failing that use foil-backed fiberglass.

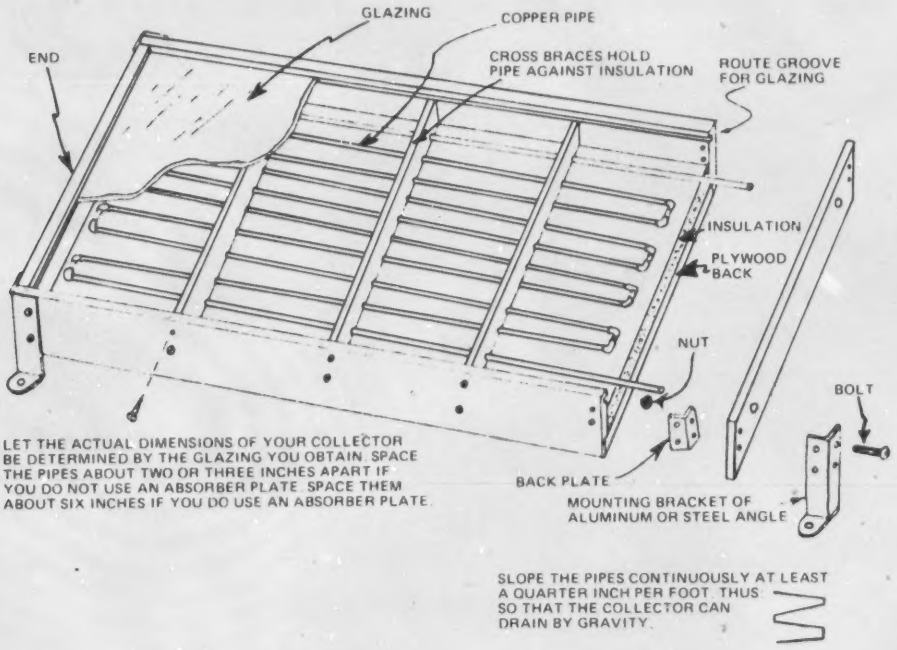
PIPE:

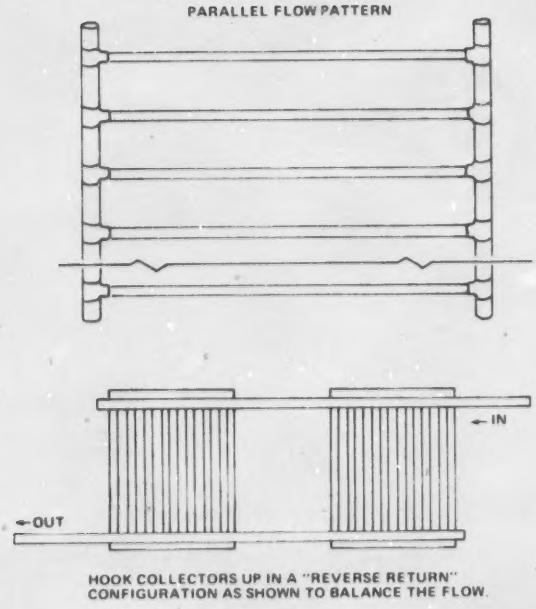
Pumped system--1/2" to 3/4" copper. Thermosiphon--3/4" copper. Be sure to have the pipes slope continuously in the collector. A slope of 1/4" per foot is adequate.

Properly constructed, this "absorberless" collector will perform better than many commercial collectors of standard design. It is left as an exercise for the curious to explain its operation. It is not necessary to follow the design rigorously, in fact, please consider the following suggestions for modification:

- o If you're handy with a torch, use a parallel flow pattern.
- o If you're handy with sheet-metal, fold up a box which is more weather resistant than wood. (Be sure to insulate the sides and the inlet and outlet pipes outside the box!)

o If you want to have an absorber plate, go right ahead! Use thin (3- to 5-ounce) copper sheet. This is perfectly adequate for 6" tube spacing, and much less expensive than the 16-ounce plate usually specified. (If it looks wrinkly, so what?!)


GLAZING
COPPER PIPE
END
CROSS BRACES HOLD PIPE AGAINST INSULATION
ROUTE GROOVE FOR GLAZING
INSULATION
PLYWOOD BACK
NUT
BOLT
LET THE ACTUAL DIMENSIONS OF YOUR COLLECTOR BE DETERMINED BY THE GLAZING YOU OBTAIN. SPACE THE PIPES ABOUT TWO OR THREE INCHES APART IF YOU DO NOT USE AN ABSORBER PLATE. SPACE THEM ABOUT SIX INCHES IF YOU DO USE AN ABSORBER PLATE.
BACK PLATE
MOUNTING BRACKET OF ALUMINUM OR STEEL ANGLE
SLOPE THE PIPES CONTINUOUSLY AT LEAST A QUARTER INCH PER FOOT. THUS SO THAT THE COLLECTOR CAN DRAIN BY GRAVITY.



Here are some useful hints:

- Be sure to orient the collector so it can be drained in the event of freezing weather.
- Don't think you can use two or three of these collectors to heat your swimming pool. Better yet, don't think about heating your pool until long after you've thought about covering it to reduce evaporation, which is the major heat loss.
- Be sure to put valves on both the collector feed and return lines, so that the collector can be isolated and drained without interrupting your domestic hot water service.
- Check valves usually don't (work).
- Anchor that collector securely! In Florida especially, collector mounting is crucial. In a hurricane (there will be a hurricane) a poorly-mounted collector will blow off your roof and kill one of your neighbors. Big (3/8") lag screws solidly into rafters is the minimum imaginable fastening. U-bolts around rafters is a better method. And make sure you have a good fastening to the collector itself!
- Should the consumers afflicted with commercial syndrome berate your collector as non-cosmetic, please point out that, "It may be ugly, but it works hard!"

Investigating Solar Tea

Energy is needed to heat water (calculate how much!), so many energy conscious people have turned to solar energy for making tea. Simply place a tea bag and a liter of cooled water in a clear glass jar, add a teaspoon or so of honey, cover the jar and place it in the sun for a few hours. The color of the tea will tell you when it's done (a little experience helps). The tea should cool to room temperature, then be refrigerated and drunk as is or with a little lemon added. If you plan to serve solar tea over ice, it's best to use two tea bags per liter.

Solar tea requires less energy to make, seems less bitter, retains the tea flavor better, and won't turn cloudy after being refrigerated. But these are not very scientific observations. Here are some suggestions for investigating solar tea:

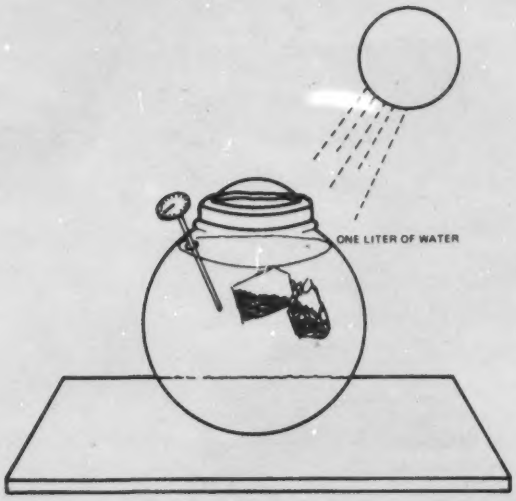
1. Prepare a liter of tea by the solar method and another by the boiling water method. Use one tea bag for each. Compare the two for intensity of color, clarity and taste. Store the two samples overnight in a refrigerator and repeat the comparison. What changes occur? Use a pH meter or short-ranged pH papers for the final determination, and compare the acidity of the two samples.
2. Measure the temperature rise as a function of time. Using a jar of plain water as a control, compare temperatures with the jar of solar tea as it brews. How can you modify your solar teapot to reach even higher temperatures? Will it reach higher temperatures on a reflective surface than on an absorbing surface? Place one jar of tea inside a sunny classroom window and another outside the window. Does the extra glass make any difference? What happens when you steep tea in the dark?

Modified from: Brewing Solar Tea, The Science Teacher, January 1980.

3. Calculate how many calories of heat your tea gained. Example: Suppose your tea gained 10°C. Since you used a liter of water, and since a calorie is 1 ml of water gaining 1°C, then

10°C x 1,000 ml = 10,000 calories

How many calories does it take to bring a liter of water to boiling? How much energy did you save by brewing tea? (Be careful!)



GOING FURTHER

Neither the sun nor boiling water is necessary for making tea. The boiling water method is faster but requires the input of nonrenewable energy. Solar tea takes 3 to 6 hours, but requires only renewable solar and human energy. Tea steeped in the dark requires human energy and patience.

A 10°C rise in temperature is not unusual, and many chemists feel that this minor change in temperature will double the rate of a chemical reaction. Besides, most substances are more soluble at higher temperatures. Boiling water obviously extracts more tannins and alkaloids than does water at room temperature or slightly higher. For example, caffeine is soluble to the extent of 67 g per 100 g of water at 100°C, but only 2.2 g per 100 g at 20C.

As the tea solution becomes darker, it absorbs more energy, causing the extraction to proceed more rapidly, and the tea becomes still darker. This simulates an autocatalytic reaction.

Students enjoy this activity because it involves familiar materials and demonstrates a simple way to save energy. Depending on grade level and the sophistication of the experiment, students can learn a variety of techniques and scientific principles. Best of all, the research has an immediate payoff in a delicious, refreshing product.

A Solar Air Heater

Solar air heaters are designed to capture and retain solar radiation as heat until it is needed for useful work. The south window of your home allows the winter sun to enter, warming the inside air. A solar air heater attempts to use this principle to provide space heating. Incoming radiation passes through a cover of glass or suitable plastic and is absorbed and retained as heat by blackened metal (usually copper or aluminum). This creates a "greenhouse effect." The amount of energy absorbed can be increased by making the surface area larger. Fasten aluminum beverage cans to the metal in such a way that air flows past the cans easily. While this provides more effective heat transfer to the passing air, it also increases the surface from which heat is lost to the surroundings by radiation and conduction through the cover. Several experiments can be designed using your collector with and without the cans.

Materials

Two 1' x 1' squares of flat aluminum sheet 0.040" thick, duct tape, glazing compound, glue, aluminum beverage cans, aluminum screws, 1" x 3" wood strips as required, electric drill, one 13" x 13" window glass, flat black paint, nails, band saw, fiberglass insulation, and a thermometer (capable of measuring temperatures up to 300°F).

Procedure

1. Cut the cans in half with a metal-cutting band saw.*

2. Position the cans about 1/2 inch from each other in rows and stagger the rows so that the central axis of each can lies between the cans in the adjacent row(s). This will allow the air to flow past more surface area than if the cans were all aligned. Leave a 1-inch border around the edges so that the plate beneath the cans can be easily mounted on the frame.

* Whole cans may be used; just modify the frame.

3. Select the appropriate size drill bit for the screws, and drill a hole in the center top and bottom of each can half and at each position on the flat plate.

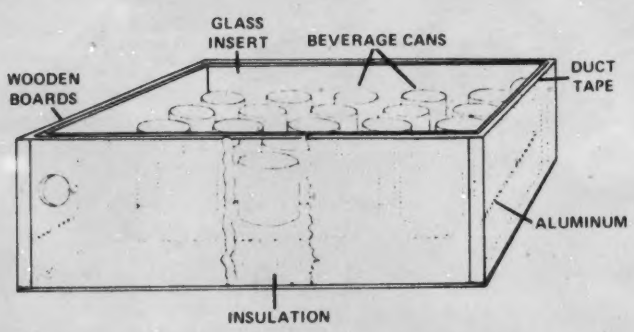
4. Fasten the cans to the plate with screws, making sure that good contact is made with the plate and the rims of the cans to permit heat transfer by conduction.

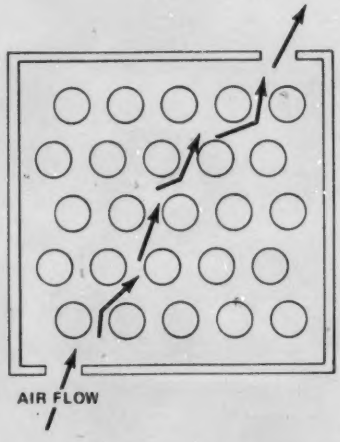
5. Construct a square wooden frame, 1' x 1' x 3" high, using nails and glue. Make a 2-inch entrance port and a 2-inch exit port on opposite sides of the frame. Insulate the bottom and sides of the frame to prevent heat loss.

6. Fasten the plate with the cans into the 3-inch-high frame, using small nails. Use glazing compound between the plate and frame to keep the bottom of the collector airtight. This compound can be used in the joints of the wooden frame if necessary.

7. Spray paint the plate (both sides) and cans flat black to make the collector a good absorber of the sun's radiation.

8. Mount the glass plate on the front of the collector, using glazing compound between the frame and the glass. Duct tape can be used to fasten the glass.





Experiments

1. How much heat can be gained by one collector volume of air?
   a. Determine the volume V of air in the collector

      $V = H \times W \times H$

   b. Determine the mass M of air being heated from the density D of air (about 0.08 lb/ft^3) and the volume V

      $M = D \times V$

   c. Calculate the heat gain ΔH by

      $\Delta H = M \times S \times \Delta T$

      where S is the specific heat of air (.24 Btu/lb 1F°) and ΔT is the temperature difference between the entrance and exit ports.

2. Design and build a convection current monitor that will turn as warm air exits the collector. This fan-like device can be built like a pinwheel and is necessary to measure the amount of air that moves through the collector. The two most important variables to study are rate of air flow and the variations in ΔT. Experiment with the current monitor to develop a flow index such as 120 turns per minute or two turns per second.

3. Calculate the required size of a solar air heater to change the temperature in your classroom 10°F.

Biogas*

The anaerobic fermentation of animal and vegetable waste is a good way of making fuel. A mixture of chicken waste and vegetable matter (like grass clippings) will produce a biogas containing up to 60 percent methane (CH_4), over 35 percent unburnable carbon dioxide (CO_2), and a combination of hydrogen and other gases. This mixture will have about 550 to 650 Btu per cubic foot. The slurry left at the bottom of the digester makes an excellent additive for cattle feed or can be used as fertilizer.

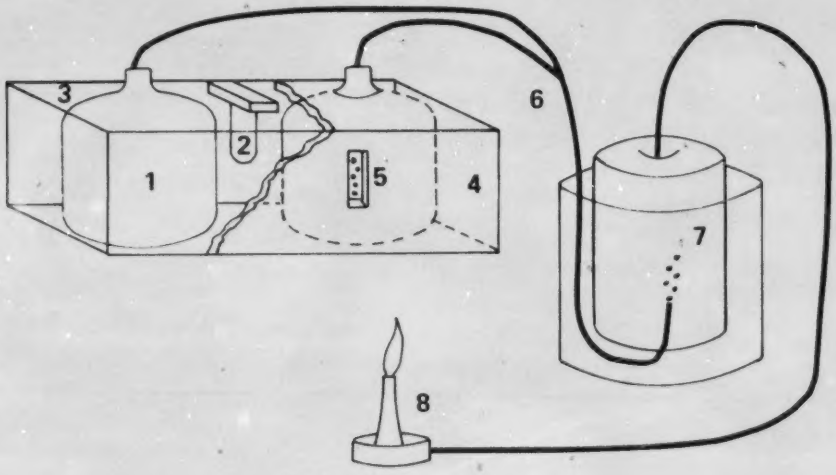
Methane could replace about 8 percent of the natural gas we use if all manure and conveniently collectable garbage were digested. Clearly the methane digester is not a total solution to the energy shortage, nor is it a practical proposition for a single family--the wastes produced by an average family would not generate enough gas to supply its needs. A farm, however, is an ideal place for a methane digester, where it can supply fuel and fertilizer and also help solve the manure disposal problem. City waste disposal costs will make it practical to produce methane using a combination of solid waste and sewage sludge.

How Does It work

The process that goes on inside a digester takes place in several stages. When the digester (material to be digested) is first loaded, bacteria begin to break down the organic matter, turning it into water and carbon dioxide. The bacteria need oxygen to do this, thus they are called aerobic bacteria. When the oxygen inside the digester is used up, a different set of bacteria takes over to continue the breaking down function. Because they work in oxygen-free conditions, these bacteria are called anaerobic. It is the anaerobic fermentation process that eventually produces methane.

* Modified from "Chicken Power"; Energy Management Center, Pasco County Schools

Building a small batch-fed digester is a simple project. Since high temperatures or pressures are involved, the digester can be almost any airtight container. Size and shape do not matter; good digesters have been made from inner tubes, oil drums, and even pressure tanks. A number of variables influence how much methane is produced, but since the digest is mixed half and half with water, figure about 25 cubic feet of gas for each cubic foot of digest. Consider the digester's maximum capacity to be about 85 percent of the volume, since some space must be left at the top in case of foaming.



BIOGAS DIGESTOR

PARTS:

1. **Bottle filled with chicken manure, grass clippings and water--called slurry.**
2. **Aquarium heater maintains slurry at 36° C.**
3. **Aquarium water jacket surrounds bottles filled with slurry.**
4. **Styrofoam insulation helps maintain 36° C.**
5. **"Window" allows student to watch anaerobic decay.**
6. **Tubing to carry off biogas from bottles.**
7. **Holding tank to store biogas.**
8. **Burner to test biogas.**

Modified from: Chicken Power, Energy Mgm't. Center, Pasco Co., Fl.

The digester shown here uses a digest of 50 percent chicken manure and 50 percent grass clippings mixed with water to produce about six cubic feet of biogas per pound of digest. If left alone, the solid materials settle to the bottom, and gas production decreases. Frequent agitation keeps the materials in contact with the bacteria and also helps prevent scum buildup. After three to four weeks, most of

the material will be digested, and the spent liquid and sludge should be removed and a new batch started. Save some of the sludge to start the new batch, and put the rest on your garden. The spent sludge contains more nitrogen than ordinary compost!

Experiments and Projects

1. Explore the effect different digests have on gas production. What other variables are involved, and how can you control them for your experiment?

2. Find out about the methane digester at Bartow, Florida, operated by Kaplan Industries. Report your findings to the class.

3. Develop a chart showing the end-use of various types of fuels and how methane can be used (or not used) to replace them. Be certain you have data to support your answers.

4. Obtain information on Ram Bux Singh and his contribution to the building of methane digesters in India.

Making Parabolas

Parabola is a term which gets tossed around a lot in the solar field. Expressed mathematically by the formula $y^2 = 4ax$ (where a = the focal length) parabolas are curves which will reflect incident light onto a single focal point or line.

Parabolic reflectors are used to concentrate large amounts of solar energy onto a small area. They are employed in a wide range of solar applications; from cookers to water heaters to photovoltaic systems. Since solar demonstration/education projects often use parabolic curves, we thought it would be valuable to show how one can be made. A simple, fast, and fairly accurate method for drawing a parabola is presented below.

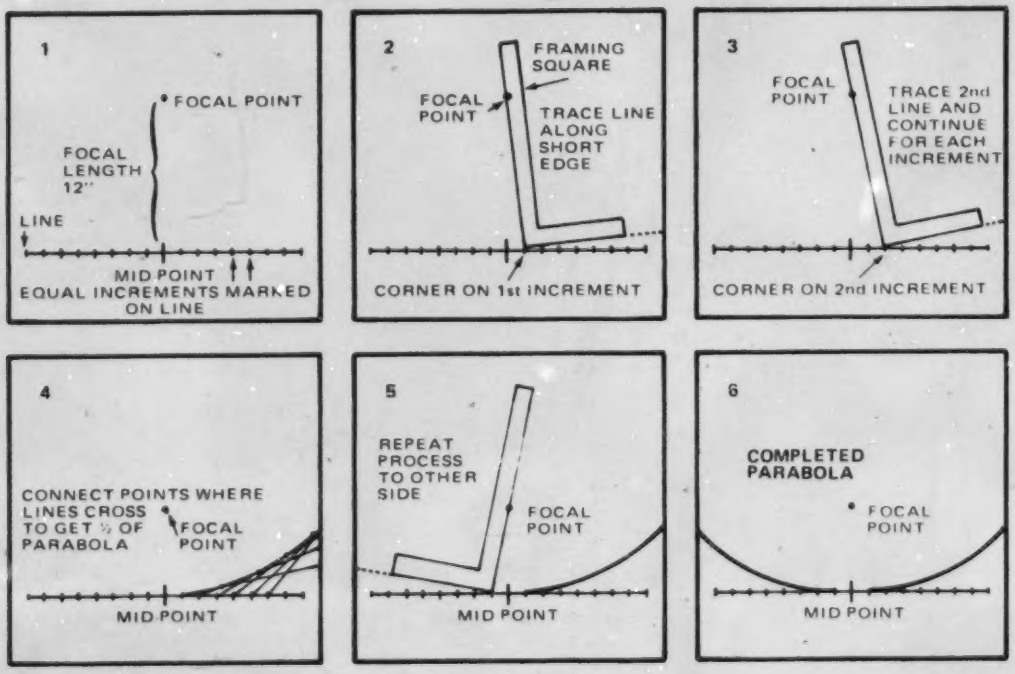
MATERIALS: carpenter's framing square, pencil and paper.

METHOD:

1. Choose a focal length (12" is a good focal length for a solar cooker). The smaller the focal length the tighter the curve of the parabola.
2. Draw a line across the bottom of the paper. Mark the mid-point of the line.
3. Make a dot one focal length (12" in the example) above the mid-point of the line. This will be the focal point of the parabola.
4. Starting at the mid-point, mark off standard increments in both directions along the line. They can be 1/4", 1/2", 1", etc., but they've all got to be the same. The smaller the increments, the more accurate the resulting parabola. Don't use increments smaller than 1/4"--the paper will get too cluttered with lines.
5. Place the framing square on the paper with the short side flush against the line and the long side passing through the dot representing the focal point.

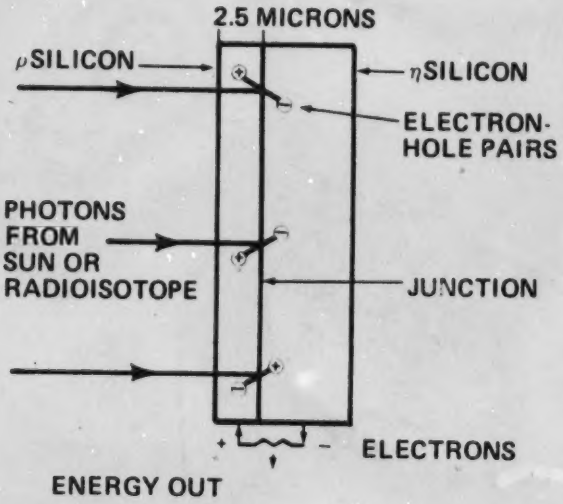
6. Keeping the edge of the long side on the focal point, slide the framing square to the right until the corner of the square touches the line at the first increment mark. The short side of the square will now be slanting slightly up to the right. Trace a line along the short side.
7. Slide the square again, to the next increment. The short side will be slanting more steeply than before. Trace a line along the short side.
8. Continue this process for all the increments marked to the right of the mid-point. The lines traced at each step will cross each other. Connect all the points where the lines cross; this will form a curve which represents one-half of the parabola.
9. Repeat this process on the left side of the mid-point, making sure to first flip the square so that the short side rests along the line pointing to the left.

For those of you who are totally confused by verbal directions, these diagrams should help:



Investigating Solar Cells

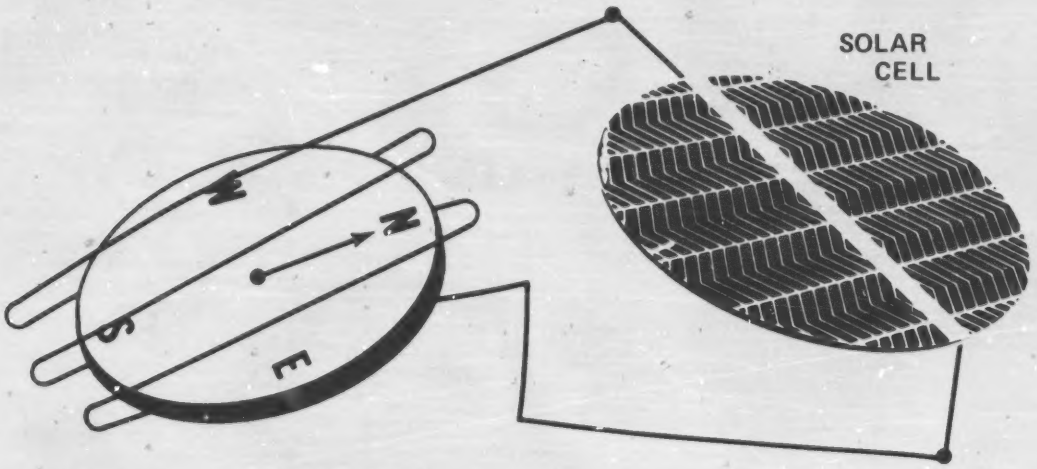
Although there are several ways solar energy can be converted to electricity, the most promising method seems to be the "photovoltaic effect." Photons, the "particles" that make up light beams, can knock electrons loose from some kinds of atoms. The solar cell uses this property of light and the unusual properties of semiconductors to produce an electric current. A semiconductor consists of a junction between two dissimilar materials. A typical arrangement is shown below:



The p-region is transparent to light and very thin (about 0.001 inch). Photons entering this region release electrons from the silicon atoms. The electrons flow in one direction across the junction as the holes move in the opposite direction. This sets up a potential difference, a voltage, and if circuitry is provided current will flow--electrons toward the positive end and the holes toward the negative terminal. A good solar cell produces about 0.03 amperes (0.5 volts) per square centimeter; and the maximum power that can be generated in full sunlight is about 0.015 watts per square centimeter.

Measuring Cell Output

Photovoltaic (solar) cells can be purchased from local electronics shops, and the output of these cells can be measured by means of a compass. Loop thin copper wires (the kind found in discarded telephone cables works well) around the compass four to six times (experiment a little!) from north to south. Attach the ends of the looped wire to your solar cell and you are ready to start. The movement of electricity through the looped wire (coil) produces an electromagnetic effect, causing the compass needle to deflect proportional to the amount of current being produced by the solar cell. The size (degree) of the deflection is affected also by the number of loops in the coil. Increase or decrease the number of loops until you get a needle deflection of about 90°.



Going Further

1. Calibrate the output of your cell over a few hours by graphing the amount of deflection measured by compass degrees over time.

2. Calculate the solar insolation: number of blocks under the curve you draw X area of the cell in cm^2.

3. Compare various kinds of filters (sunglasses) and their effect on the cell's output.

4. What happens when you connect cells in series? In parallel?

5. Which colors reflect more light? Investigate different surfaces of the same color.

6. Which gives off more light: incandescent or fluorescent bulbs?

ECONOMICS WORKSHEET

The average annual residential electrical energy consumption is about 12,000 kilowatt hours. About 25 percent of this energy is used to heat water. On the average, how many kilowatt hours are used to heat water?

kilowatt hours/year	=	amount used for water heating	=	energy for water heating per year

Electricity from the company that serves most of central and southern Florida costs about 5 cents per kilowatt hour for homes. What is the average annual cost to heat water?

energy used	X	average cost	=	average energy cost for water heating per year

Electric rates are increasing about 10 percent per year. If these rates continue to increase, electricity will cost 1.75 times more over a 10-year period. Calculate the average annual cost for water heating over the next 10 years.

average energy cost for water heating per year	X	average rate over next 10 years	=	average annual cost for water heating for next 10 years

Since this is a 10-year average, the total cost would be 10 times the average annual cost. In most of Florida, a solar water heater will supply about 70 percent of the energy needed to heat water. Calculate the average annual savings over the next 10 years that a solar water heater could provide.

water heating costs for next 10 years	X	amount of energy supplied by the sun	=	total energy savings over 10 years

A solar water heating system costs about $1,000 if you install it and about $1,500 if you hire someone to install it. Is the investment worthwhile? What are some other reasons to purchase and install solar water heaters?

SUNDIALS

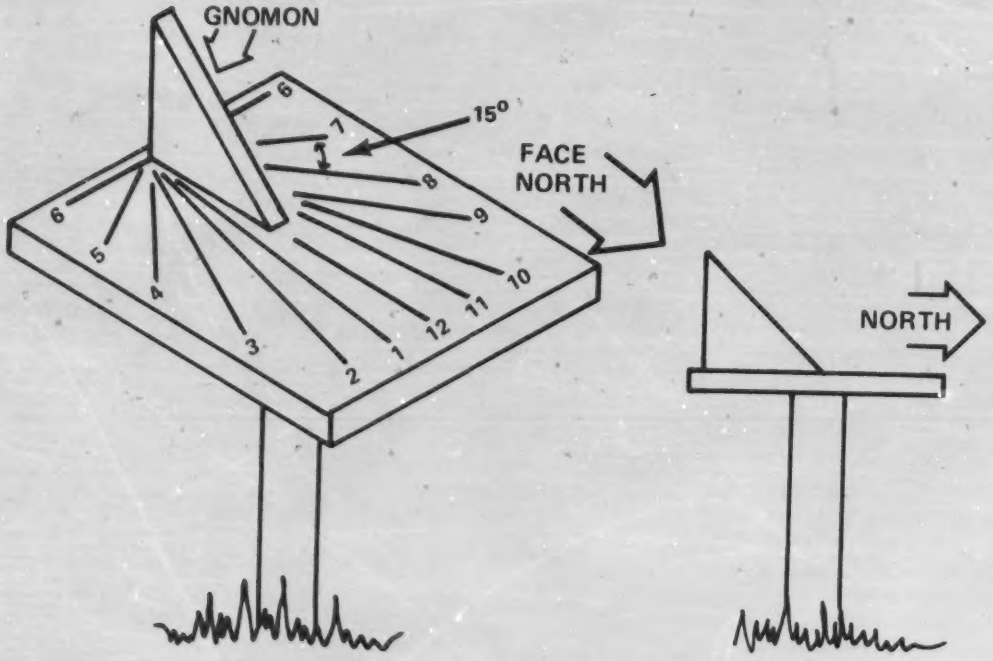
Materials: wood or heavy cardboard, nails, glue.

Procedure:

1. Cut a base for a flat sundial.
2. Find the latitude of the location and subtract this from 90^{o} to determine the angle of the gnomon (the sundial's "pointer").
3. Mark the angle (the remainder) on a section of wood with a protractor, then cut out the gnomon.
4. Mount the gnomon to the base, using nails and glue. Position it as shown in the illustration.
5. Mark the numeral 6 on the outer edge of the base in line with the gnomon. The gnomon represents the numeral 12.
6. Set the sundial in a level open area with the numeral 12 pointed north.
7. Mark the other numerals according to the gnomon's shadow and your watch, 15 degrees apart.

Questions:

1. Is there any difference between the mean solar time and the time kept by your watch?
2. Did any early peoples use the sundial to tell time? What kinds of sundials?
3. Can you improve the accuracy of your sundial?
4. How will seasonal changes affect your sundial?



ACTIVITIES FOR ELEMENTARY SCHOOL*

* Selected from "Energy and My Environment (K-6)" by Matthew Brennan

ACTIVITY 1

Objective: To discover that we get light from the sun.

Introducing the lesson:

1. Go outside and sit in the sun. Ask the children to feel the light of the sun reach into them. (Explain that light is another kind of energy from the sun in addition to heat.)

Developing the lesson:

1. Ask the children to tell how they enjoy the light from the sun.
2. Ask: "How is the light different from the dark?" (It is dark when there is no light; we can't see.)
3. Ask: "What do we do when it is dark?" (We use another kind of energy to light things--electricity.)

Extending the lesson:

1. Ask the children to make up a story about their energy reaching out to the sun.
2. Ask: "Do all living things like the sunlight as much as you do?" (No. Some animals come out only at night. Others live in dark caves and tunnels.)
3. Draw a picture of yourself enjoying the sun's energy.

ACTIVITY 2

Objective: To discover the effects on humans of the radiant energy from the sun.

Introducing the lesson:

1. Go outside the school to enjoy the sun's energy--say "hello" to the sun. (sunrise, sunset, heat)

2. Sit in the sun for a little while and make a list of the ways you can enjoy the sun. (heat, light, plants, animals, wind)

Developing the lesson:

1. Although the process will not be understood (that is not necessary now) explain that the sun helps green plants to make and store our food.

2. Draw picture which shows a "sun farmer" using the sun to grow plants.

3. Say "thank you" to the "sun farmer" for your food.

4. Think sun! Think of what the sun does for you--think of fire, heat, light, beauty, sunsets.

Extending the lesson:

1. Ask the children to look on the boxes of food in their homes for pictures of the sun making the food (cereal, etc.) and bring in the empty boxes.

2. Make a collage picture of the sun's energy being used by plants to make food, using the children's pictures from food boxes.

3. Have the children do a dance to show how they enjoy the sun's energy.

ACTIVITY 3

Objective: To discover the relationship between moving air and energy--that moving air has energy.

Introducing the lesson:

1. On a windy day, take the class outside. Let a few sheets of paper blow from your hand (in a place where there are no cars).

2. Ask the children to catch the papers.

Developing the lesson:

1. Ask: "What is needed to make something move?" (energy)

2. Look for other things that are being blown by the wind. (flag, trees, hair, clothes)

3. Ask: "How do people use the energy of the wind (moving air) to move things?" (sailboat, fan)

4. Be your own wind. Blow out a candle, blow away a seed.

Extending the lesson:

1. Ask the children to:
   a. draw a picture of a sailboat on a calm day (no wind).
   b. move like the wind (children will be very creative--blown by the wind as a leaf, a bird, a paper; jumping into clouds; being blown away; snowing).

2. Catch the wind. Make a sail with your jacket.

3. Ask: "Does moving air have energy?" (yes)

4. Tell a story about a seed being moved by the wind.

ACTIVITY 4

Objective: To discover the relationship between the sun's energy and the energy we use.

Introducing the lesson:

1. Open the window drapes or shades and let the sun shine in.

2. Ask: "What happens when we let the sun shine into the classroom?" (heated, lighted)

Developing the lesson:

1. Ask: "How can we show that we can get heat from the sun indoors?" Feel the window sill, put a cold object on window sill and leave it for a few minutes, feel the sun on backs.

2. "Let's go outside and see if we get heat from the sun outdoors." If it is a cold day it may be harder to do. Sit with backs to sun. Feel children's clothes. Compare dark and light clothes.

3. Ask: "What other kind of energy do we get from the sun?" (light)

4. Compare places in the sun with places in the shade. Ask: "Which is hotter? Which is lighter?"

Extending the lesson:

1. Go outside and look for ways people use heat from the sun. (swimming, sunbathing, drying laundry)

2. Ask the children how their parents use the heat of the sun at home. (sunbathing, growing plants, heating swimming pool, porches and patios)

3. Look for ways people keep the heat of the sun out of buildings. (drapes, blinds, awnings)

4. Draw a picture of people using the sun's energy.

ACTIVITY 5

Objective: To discover that the energy of the sun is used by people.

Introducing the lesson:

1. Turn off the lights and darken the room enough that it is too dark to look at pictures.
2. Tell the class you are going to show them some pictures of people using the sun's energy.
3. Hold up several pictures of people growing plants, sitting in the sun, etc.
4. Ask: "Why are we having so much trouble seeing the pictures?" (not enough light)
5. Ask, "How can we get more light?" Turn on lights, open drapes.
6. Let the child who suggested opening the drapes open them. Do not turn on the lights yet.

Developing the lesson:

1. Ask the children to pretend that there are no electric lights.
2. Ask: "Is the light enough for use to see the pictures now?" Show the pictures again.
3. If there is enough light, ask: "Where does the light come from?" (the sun)
4. If it is still too dark to see the pictures well, take the class outside the school and show them the pictures.
5. Ask: "How have we used the sun's energy?" (light energy to see)

Extending the lesson:

1. While the class is outdoors, review what they have learned about heat energy from the sun.
2. Look for a place where the grass is covered with a board or paper. Remove the board or paper. The grass will be yellow or dead. Ask: "Why is the grass yellow or dead?" (no sunlight; no energy from the sun)
3. Draw a picture of our school without the sun's energy.

ACTIVITY 6

Objective: To give children the opportunity to discover that light is a form of energy from the sun.

Introducing the lesson:

1. If you do not have a window in the classroom into which the sun shines, take the class to the cafeteria, auditorium, library or any room with sun coming in the windows.

2. Partially close the drapes or place a piece of cardboard or oaktag with an odd-shaped hole in it so that the sunlight comes through and makes a light spot on the floor or on dark paper.

3. Ask the children to find a ray of light coming through the crack in the drapes or hold in the cardboard and watch it change. (It moves, changes shape.)

Developing the lesson:

1. Ask the children to feel the light.

2. Ask the children to describe the light.

3. Ask the children to draw a picture of themselves inside the ray of light.

4. Ask the children to describe their pictures.

Extending the lesson:

1. Take the class outside and demonstrate how a magnifying glass can focus (gather) the rays of light on a paper and burn a hole in it.

2. Ask: "Is there heat in the sun's rays?"

3. Ask: "What kinds of energy do we get from the sun?" (heat and light)

4. Ask: "Can the sunbeam be your new friend?"

5. Ask the children to use energy words in a sentence.

ACTIVITY 6

Objective: To give children the opportunity to discover that light is a form of energy from the sun.

Introducing the lesson:

1. If you do not have a window in the classroom into which the sun shines, take the class to the cafeteria, auditorium, library or any room with sun coming in the windows.

2. Partially close the drapes or place a piece of cardboard or oaktag with an odd-shaped hole in it so that the sunlight comes through and makes a light spot on the floor or on dark paper.

3. Ask the children to find a ray of light coming through the crack in the drapes or hold in the cardboard and watch it change. (It moves, changes shape.)

Developing the lesson:

1. Ask the children to feel the light.

2. Ask the children to describe the light.

3. Ask the children to draw a picture of themselves inside the ray of light.

4. Ask the children to describe their pictures.

Extending the lesson:

1. Take the class outside and demonstrate how a magnifying glass can focus (gather) the rays of light on a paper and burn a hole in it.

2. Ask: "Is there heat in the sun's rays?"

3. Ask: "What kinds of energy do we get from the sun?" (heat and light)

4. Ask: "Can the sunbeam be your new friend?"

5. Ask the children to use energy words in a sentence.

ACTIVITY 7

Objective: To discover the energy of the sun's radiation on the earth.

Introducing the lesson:

1. Wet two paper towels in a dish of water or under a faucet.
2. Ask: "How can I get these towels dry again?"
3. When the alternatives--"put them in a clothes dryer" or "hang them in the sun," etc., have been given by the children, say "Let us go out and see if the energy of the sun can dry the towels."

Developing the lesson:

1. Have the children decide where to place the towels (be sure that one is placed in the shade).
2. You may wish to wet more towels so that other methods may be tried.
3. Compare hanging towels with towels left on the ground.
4. Compare towels in the sun with towels left in the shade.
5. Compare windy and calm places.
6. Note: Explain that wind is air that is moving because it has been heated by the sun, thus the energy from the sun can dry the towels directly (with heat) or indirectly (by evaporation).

Extending the lesson:

1. Ask: "Why do you think so many people dry their clothes in an electric dryer instead of hanging them in the sun to dry?" (You will get some great answers--air too dirty, too much work, machine drys clothes at night or on rainy days, outside is too messy, live in an apartment, no room, etc.)
2. Do a class survey to see how many of the children's parents use the sun to dry clothes.
3. Do a survey of how grandparents dried their clothes.

ACTIVITY 8

Objective: To discover the relationship between energy and the wind.

Introducing the lesson:

1. Take the children outdoors, gather them in a circle around you, and ask them to take 20 steps away from you and look for something being moved by the wind.

2. Ask them to come back to the circle around you as soon as they have found something being moved by the wind, but not to tell anyone what they have found.

Developing the lesson:

1. Ask the children one by one to come to the center of the circle and move like the something they found. Tell them not to tell anyone what they found.

2. Have the rest of the class try to guess what it was that each child found being moved by the wind.

Extending the lesson:

1. Ask: "When the wind moves thing, is it using energy?" (yes)

2. Ask: "Where does the energy come from?" (sun)

3. Ask the children which movement they like best. Let them all try to do that movement. They will have created a dance which shows how the energy of the wind moves things.

4. Using movement, compare the energy in a gentle breeze with energy in a gale.

5. Ask about personal experiences with wind (hurricanes, gales, dust storms.

ACTIVITY 9

Objective: To discover the relationships between animal lives and the sun's energy.

Introducing the lesson:

1. On a bright sunny day, take the class outdoors to look for examples of how living things use solar energy directly. Do not help the students or make suggestions.

2. Have each student make a list of the examples found.

Developing the lesson:

1. Make a class list of the examples of direct use of solar energy observed. (The list should include uses of sunlight--to see, help green leaves make food, etc; and sun heat--to warm bodies, etc.)

2. Ask: "How has nature designed living things to collect solar energy?" (leaves broad and flat; tree branches spread out; animals darker colored on top; water animals, turtles and snakes designed to crawl on logs for sun baths, etc.)

3. Draw a picture showing how man has designed things to use solar energy directly.

4. Describe your picture.

Extending the lesson:

1. Investigate how cold-blooded animals use solar energy in reproduction. (Snake and turtle eggs are laid in sand which is warmed by sun. Alligators lay their eggs in piles of grasses and mud; the heat from the sun speeds up the decay of the grasses and produces heat to incubate the eggs.)

2. Use some art form to describe an animal's use of solar energy.

3. Ask: "How are people like other animals in their use of solar energy?" (sun bath, etc.)

4. Investigate the dangers to the eyes and skin from too much solar energy (sunburn, cancer, blindness).

ACTIVITY 10

Objective: To discover the relationship between energy loss and insulation.

Introducing the lesson:

1. Take the class on a survey tour of the school to find examples of heating or air conditioning energy being wasted. Do not help the students or make any suggestions.

2. Ask each student to quietly make a list of the examples found.

Developing the Lesson:

1. Make a class list of examples of heat energy loss. (This should include loss of heat through windows, doors, uninsulated pipes, hot water use and waste.)

2. For each item on the class list, have the students suggest how the waste could be eliminated or reduced. (insulation)

3. Now take the class outside and look for more examples of heat energy being lost or wasted.

4. Ask: "How could the lost energy be restored?" (It cannot. Heat energy lost is gone forever.)

Extending the lesson:

1. Find examples of efforts to get rid of heat energy. (fan to cool auto engines; cooling tower in electric power plant, exhaust fan in kitchen, etc.)

2. Draw a picture of heat energy being lost.

3. Describe your picture.

4. Evaluation: Use the word "insulation" in sentence or short story.

ACTIVITY 11

Objective: To discover the relationship between energy forms and energy storage by people.

Introducing the lesson:

1. Light a candle or an alcohol lamp.
2. Let it burn until the burning has stimulated several of the senses.
3. Ask one of the students to investigate whether heat energy is being given off.
4. Ask: "What is the source of the heat and light energy in the candle?" (wax--stored plant oils)

Developing the lesson

1. Find evidence of stored energy in the classroom and school building and on the school grounds. (food, batteries, water pressure, candles, seeds, fuel tanks, etc.)
2. Go out and find people storing energy.
3. Make a list of what you found.
4. Investigate how people use stored energy as power.

Extending the lesson:

1. Prove that there is energy stored in:
   a. the water behind a dam. (Build one!)
   b. a battery. (Light a flashlight, start a motor.)
   c. food. (Burn it.)
   d. a fuel. (Burn it.)
2. Find out how other animals store energy.
3. Investigate how plants store energy. (as fat oils, carbohydrates, and proteins, stored in the part of the plant people use as food)
4. Draw a picture of stored energy being used:
   a. to make electricity. (coal, oil, water power)
   b. to move something. (water wheel)

ACTIVITY 12

Objective: To discover the relationship between solar energy and the life-styles of people.

Introducing the lesson:

1. Write on the chalkboard: "The sun supplies most of the earth's radiant energy."

2. Ask the students to write out their reasons that they agree or disagree with the statement.

Developing the lesson:

1. Discuss with the students their reasons for agreeing with the statement. (All stored food energy--wood and forage--is stored by green plants using solar energy directly. All of our fossil fuels were stored ages ago by green plants and by animals that ate green plants, both of which were buried in the earth's rocks. Thus, fossil fuels are indirectly supplied by solar energy--for example, coal, natural gas, and oil.)

2. Discuss reasons for disagreement. (large amount of nuclear power from the hot interior of the earth)

3. Ask the students to list the sources of energy which are not solar. (nuclear, geothermal)

4. Ask: "How about wind power?" (Wind is air moving because of uneven heating by the sun over different parts of the earth.)

Extending the lesson:

1. Investigate the major ocean currents:

   a. warm--moving from the equator.
   b. cold--moving from the poles.
   (both resulting from uneven solar heating over different parts of the earth.)

2. Draw a picture of yourself or a friend enjoying some solar energy:

   a. directly. (sunbath)
   b. indirectly. (sailing)

ACTIVITY 13

Objective: To discover the relationship between solar energy and the climates of the world.

Introducing the lesson:

1. Have the students collect advertisements which feature Florida's climate.

2. Make a bulletin board display of the advertisements.

3. Ask: "What can we learn about the attraction of Florida's climate on housing, tourism, fishing and other industries that might wish to come to Florida?"

Developing the lesson:

1. Investigate the reasons for Florida's warm climate. (geographical location, amount and intensity of the sun, angle of the sun's rays, etc.).

2. Ask: "What does the term "tropical" mean?"

3. Compare the length of daylight and the average yearly temperature of your community with that of Chicago; Atlanta; Washington, DC; and Anchorage, Alaska.

4. Consider other factors which influence Florida's climate which are indirectly related to the radiant energy of the sun. (Gulf stream, warm waters of the Gulf of Mexico, summer showers)

Extending the lesson:

1. Investigate the effects of Florida's warm, sunny climate on:

   a. population--growing rapidly, older than average.
   b. tourism--a warm winter vacation place.
   c. industry--fishing, housing, agriculture (winter crops).
   d. wildlife--winter home.
   e. any other.

2. Draw a picture of a tourist enjoying a Florida vacation.

3. Describe your picture, telling how the climate affects the activities shown in your picture.

4. Discuss the harmful effects of the Florida sunshine. (sunburn, skin cancer, etc.)

5. Write a letter to a northern friend telling of the "wonderful climate" of your area of Florida.

6. Have the students design a billboard to be placed along northern highways telling people about Florida's climate and the life-styles of people.

7. Have the students design a billboard telling people why they should or should not come to Florida to live.

ACTIVITY 14

Objective: To discover how people throughout the ages have worshipped the sun and its energy.

Introducing the lesson:

1. Ask the students to collect pictures of the sun, sunrises and sunsets.

2. Make a bulletin board display of the pictures.

Developing the lesson:

1. Ask the students to draw a picture which expresses their feelings about the sun.

2. Find examples of modern "sun worship."

3. Ask: "How has modern sun worship affected industries in Florida?" (suntan lotions, retirement, vacations)

Extending the lesson:

1. Investigate the worship of the sun god RA in ancient Egypt. (Pyramid inscriptions on inside walls of Sixth Dynasty B.C.--depict the sun god RA carrying the Pharoah's soul on his sky boat into the west, where lay the land of the dead.)

2. Read in National Geographic magazine, November 1970, about the restoration of Akhenaton's Temple to Aten, the solar disc.

3. Investigate the Akhenaton concept of a single supreme sun god, the solar disc--the unification of all the former sun gods into one image of Aten. (This concept influenced religious thought in the Middle East until the time of Jesus and Muhammed.)

4. Read to the class and discuss this passage from the Vedic Hymns (Hindu), circa 1400 B.C.: "And when the Sun arose, they could not understand how this newborn God could wield such power. And they said, 'Let us worship this Child of Sky. He stands up as a mighty flame; he stretches wide his arms; he is everywhere like the wind.' "

5. Investigate this Vedic concept's influence on the writing of Thoreau. (See "Walden," Chapter 2, for insight into Thoreau's regard of the sun as the visible symbol of some yet-to-be-evolved human grandeur. Throughout "Walden" he compares daybreak with spiritual awakening.)

6. Have one of the students read Walt Whitman's "Song of Myself" (a primitive psychological idea that light from an inner sun is emitted through the eyes and mixes with the eternal light of the sun to

make visual perception possible--a notion as old as Empedocles, 5th Century B.C.).

7. Investigate the "CIWILTKONIA", a sun ceremony of the Papago Indians of the southwestern U.S. (Dancers circle a sand painting of the sun and thereby recharge themselves with its life-giving energy.)

8. Read to the class Franz Boas' description of the "Prayer at Sunrise" of the Pacific northwest Kwakiutl Indians, and ask the students to discuss: "Welcome, Great Chief, Father, as you come and show yourself this morning. Let nothing evil befall on me this day which you have fashioned according to your wishes, Great One, Walker-Across-The-World, Chief."

ACTIVITIES FOR SECONDARY SCHOOLS*

* Selected from "Energy and My Environment" (Grades 7-8-9) by Matthew Brennan

ACTIVITY 1
(Science, Art)

Objective: To discover the relationship between energy and the fuels and foods produced by plants.

Introducing the lesson:

1. Ask: "What is the most important chemical reaction on earth?" (the reaction in which the radiant energy of the sun is absorbed by the chlorophyll in a green plant, producing the chemical energy which sustains life on the earth)

2. Review the process of photosynthesis. (It breaks down the water and carbon dioxide taken in by a green plant to form sugar--a composite of carbon, hydrogen, and oxygen--and pure oxygen, thus capturing the sun's energy and storing it.)

Developing the lesson:

1. Investigate the storage of energy in carbohydrates and ATP (adenosine triphosphate) in living cells.

2. Ask: "How do animals use this stored energy?" (to do muscular work, keep warm, to generate nerve impulses, to make proteins and other molecules for building new cells)

3. Review the kinds of plant foods we eat, and determine the plant part which stores energy. (Usually, the part which stores most of the energy is the part we eat.)

4. Ask: "Are there any plant parts that are not used for the storage of energy?" (No, they will all burn.)

Extending the lesson:

1. Investigate the relationship between energy storage and size of seeds in a plant. (Plants that store their food in stems or roots have tiny seeds compared to corn or beans, which store their food in seeds.)

2. Design and build a dream plant which stores food in every part.

3. Ask: "Which part of your dream plant would you prefer to eat?"

4. Ask: "How would you decide?"

5. Ask: "What energy stored in plants is not available as food to people?" (Cellulose; humans do not have the digestive enzymes necessary to break down the cellulose in wood, grass, cotton, seed coats, etc.)

ACTIVITY 2
(Science, Geography, Social Studies)

Objective: To discover the relationship between different forms of energy.

Introducing the lesson:

1. Ask the class to list the possible effects of increased burning of fuels on the earth environment. (addition of heat, increased carbon dioxide, air pollution, etc.)

2. Investigate the operation of a greenhouse. (Glass lets in solar short-wave radiation but prevents the passage of long-wave infra-red radiation (heat) out of the greenhouse. A closed automobile sitting in the Florida sun is another good example.)

Developing the lesson:

1. Scientists know that carbon dioxide acts in the atmosphere like the glass in a greenhouse, keeping in the heat from solar radiation. Ask: "What effect could this have on the earth's climate?" (It would raise the temperature.)

2. Ask: "How could the increased burning of fuels contribute to the 'greenhouse effect'?" (by increasing heat and the carbon dioxide which holds it on earth)

3. Construct model greenhouses and measure the effect on inside air temperatures after exposure to the sun.

4. Measure the increase in temperature in a school bus or automobile sitting in the sun for one hour, two hours, all morning.

5. Investigate the predictions of scientists regarding the effects of the heat which will be released in the burning of the earth's remaining fossil fuels. (Some estimate a 2°F increase in the earth's temperature. Other scientists believe that the earth may grow colder as a result of the large amounts of smoke, soot, etc., released into the atmosphere, which may reflect sunlight away from the earth, thus cooling it.)

Extending the lesson:

1. If the earth's temperature should rise 2°F, scientists estimate that melting of the Antarctic ice-cap would raise the level of the oceans (sea level) by 200 feet. Assuming this happened, draw a map of the "new" United States, its low coastal areas now covered with water--including Florida.

2. Discuss other possible effects of increased energy use:
   a. transportation of oil. (oil spills)
   b. automobiles. (air pollution)
   c. urbanization. (loss of vegetation--carbon dioxide sinks)
   d. agriculture. (loss of forests--carbon dioxide sinks)

3. Investigate plans to use the increased "waste" heat for power production.

ACTIVITY 3
(Science, Social Studies, American History)

Objective: To discover the relationship between the energy of the sun and life on earth.

Introducing the lesson:

1. Ask the students to complete the following phrase: "Solar radiation is..." Consider its nature, appearance, effects, capture by plants, use by animals and man.

2. Discuss the student responses and make a list of possible topics for further discussion and investigation.

Developing the lesson:

1. Follow up on ideas for activities from the discussion above.

2. Investigate the solar architecture of the Pueblo Indians--design for heating, cooling, ventilation, illumination, and integration with natural cycles of season and climate.

3. Ask: "How does this solar architecture correspond to animal structures--bee hives, ant hills, animal burrows, birds' nests, etc.?"

4. Ask: "Why has modern man lost the art of solar architecture in the high-energy society?" (Air conditioning has replaced mental skills and ingenuity in dealing with nature.)

Extending the lesson:

1. Investigate the suggestions for siting and orientation of houses, buildings, and even cities with regard to the sun, prevailing winds, and other climatic and geographic features by the ancient Roman architect Vitruvious in the time of the Emperor Augustus.

2. Investigate the design and construction of the buildings of the Seminole and Miccosukee Indians of Florida.

3. Ask: "Why were early American barns painted red?" ("Paint" was skim milk mixed with iron rust coloring and lime, which absorbed sunlight--a "solar heating device.")

4. Predict the future for buildings like the World Trade Center twin towers, with over 100 stores and no insulation or windows that will open. Discuss how a building like this could have been designed and constructed. (Energy was so cheap that there was no reason to be concerned about the costs of heating, cooling or lighting.)

5. Investigate modern solar architecture in the U.S. to determine how it is like--or unlike--ancient solar architecture.

ACTIVITY 4
(Science, Home Economics)

Objective: To discover the relationship between energy and water evaporation.

Introducing the lesson:

1. Survey the class to determine use of appliances for washing and drying clothes. Ask: "How many of you are wearing clothes that were washed and dried without using any appliances?"

2. Determine what articles of clothing are most likely to be washed by hand and hung up to dry.

3. Now make a separate survey for washing and drying.

Developing the lesson:

1. Ask: "How many have an outdoor clothesline or dryer?"

2. The U.S. Department of Energy estimates that the average owner of a clothes dryer uses 1,000 kilowatt-hours of electric power per year. Calculate how many killowatt-hours of electric power are used by the homes of class members, using DOE's average rate.

3. How much would this cost at 5¢ per kilowatt-hour? (Florida's price)

4. From local weather records, determine the number of days last year on which clothes could have been dried outdoors in your community.

5. How much energy could be saved if all the people in your community hung their clothes out to dry? (number of homes time 1,000 kilowatt-hours per year)

6. Conduct a "clothes pole" (poll) of your neighborhood to find out how many homes have dryers and how many have outdoor clotheslines.

7. Ask: "Is there any evidence that the number of outside clotheslines is changing?"

Extending the lesson:

1. Survey radio and TV advertisements for detergents. How many emphasize the "clean, fresh smell of the outdoors" which is lost by using an electric or gas dryer?

2. Investigate why Monday was always washday.

3. Discuss how the increased use of clothes dryers relates to air pollution and urbanization.

4. Investigate the water pollution problems associated with the use of detergents.

5. Ask: "Should the use of clothes dryers be banned to save electricity or gas?" Discuss the pros and cons.

6. Ask "Is there another appliance that your family would rather give up than the clothes dryer?"

7. List the appliances in the order in which the class members would give them up in the event of a serious energy shortage.

ACTIVITY 5
(Science, Social Studies, History, English)

Objective: To discover the relationship between solar energy and moving air.

Introducing the lesson:

1. Complete the following sentence: "Wind is..."

2. Write the students' words on the chalkboard as fast as you can, no matter how unlikely they may sound to you.

3. From this list of words develop a list of opposite words which can be used to describe moving air. (for example, hot-cold; good-bad; fickle-steady; reliable-unpredictable; gentle-violent; etc.)

Developing the lesson:

1. Ask: "What do most of the words tell us about what wind is?" (moving air)

2. Investigate the atmosphere around the earth as a giant heat machine (engine) moved by solar radiation. (The rays of the sun, stronger near the equator than in the polar regions, cause tropical air to warm and rise, while cooler polar air moves in to replace it.)

3. Discuss the effect of the earth's rotation on this north-south flow of heated air. (Air moving to the north--a south wind--is deflected toward the east = a SW wind; air moving to the south--a north wind--is deflected toward the west = a NE (trade) wind.)

4. Ask: "What other factors influence the movement of air?" (local atmospheric conditions--high and low pressure systems; obstructions--mountains or high buildings; and type of surface--asphalt, land, or water--which influences local heating and cooling)

5. Discuss how a sea breeze follows this general pattern of uneven heating of the earth's surface. (Air over land heats and rises; colder air over water flows in to take its place.)

Extending the lesson:

1. Investigate the historical importance of the wind as a source of energy for people's use. (moved ships; pumped water; milled grain; etc.)

2. Investigate the windmills invented by Marcellus Jacobs of Fort Myers, Florida, to produce electricity with a wind generator.

3. Move like the kind of wind which represents each of the words used to describe it at the beginning of this lesson.

4. Draw a picture of your favorite wind and a wind you are afraid of.

5. Ask: "How do airplanes use the wind?" (take-off, landing, flight, jet stream, tail winds)

6. Investigate how wind records and other weather records are kept.

ACTIVITY 6
(Science, History)

Objective: To discover the relationship between energy and power.

Introducing the lesson:

1. The day before starting this lesson, ask each student to bring in a small mirror and a magnifying glass.

2. Take the students outside to the schoolyard. Have them try to focus the rays of the sun on a small piece of paper placed on a sidewalk or other bare area. Bring a small container of water to wet the area around the paper. Students should have no trouble burning a hole in the paper; they have used solar energy to to work.

3. Next, place a piece of paper vertically between the sun and the class. Ask the students to use their mirrors to focus the sun's rays on the paper from their position. (They will have to move forward or back to do this.)

4. After they have focused their mirrors, have them try to focus on a central spot to burn a hole in the paper.

5. Have each student measure and record the distance from the mirror to the paper. (Are they all the same distance?)

Developing the lesson:

1. According to the Greek historian, Galen, the Greek scientist, Archimedes, used solar reflecting mirrors (bronze shields) to set fire to the Roman fleet besieging the city of Syracuse in 212 B.C. by focusing the sun's rays on their black sails. On the basis of their own experience, do the students think this was possible?

2. Read about how this might have been done in the book, "Power For the People," by Allen and Marjorie Meinel.

3. Investigate the construction and operation of a solar oven.

4. Build a solar oven and use it.

5. Ask one of the students to investigate and report on the solar system engine built by the French scientist, Augustin Mouchet, in the 1860s.

6. Do the same for the work of the Swedish-American, John Ericson, in the development of solar engines.

7. Investigate the research of Frank Shuman in Pennsylvania and his development of the Sun Power Company in 1908.

8. Compare the operation of the sun furnace in the French Pyrenees (Felix Trombe) to the experience with mirrors the students had at the beginning of this lesson.

9. Investigate the use of solar power for desalting water.

Extending the lesson:

1. Ask: "How did the discovery of oil in Pennsylvania affect the development of solar power?" (Since oil was a much cheaper source of power, research was almost halted until 1973.)

2. Ask: "How have 'the times' made water desalinization important?" (water shortages and pollution)

3. Investigate how the solar power research by Dr. Robert Goddard led to his invention of the rocket engine.

4. Investigate the development of solar water heaters in Florida.

5. Design a solar still and use it to provide a drink of water.

6. Draw a picture of yourself operating a solar still.

ACTIVITY 7
(Science, Social Studies, History)

Objective: To discover the relationship between the movement of air and the energy it produces.

Introducing the lesson:

1. Ask if anyone in the class has experienced a hurricane or severe storm.

2. Ask those who have had that experience to describe the storms, emphasizing the force of the wind, the pressure it exerts, the work it can do.

3. Collect pictures and news accounts of hurricanes that have passed over Florida. Make a bulletin board display.

Developing the lesson:

1. Ask: "What is the principal 'fuel' for the earth's heat engine?" (It is water vapor in the atmosphere, holding latent energy which is transferred to the atmosphere when water is alternately evaporated and condensed in the water cycle. Wind is the most evident form of this energy.)

2. Distinguish between energy winds and prevalent winds. (Prevalent winds are common, up to five days a week, 5-15 miles per hour; energy winds--storm winds--average two days per week, 10-25 miler per hour; for example, the "northeaster" or "southwester.")

3. Ask the students to investigate the direction and average speed of the prevailing and energy winds in their area.

4. Investigate Sir Francis Beaufort's contribution to wind speed measurement.

5. Ask: "What would be the most important characteristics to consider in deciding whether to set up a windmill in your area?" (prevailing wind, regularity, best height)

6. Ask: "Would our area be satisfactory?" (Scientists say that winds needed for power production should fall between Beaufort force 3 and 6 (gentle to strong breeze); higher winds may be destructive.)

7. Investigate the use of wind to pump water throughout history.

8. Find out how "sails" made windmills more efficient.

Extending the lesson:

1. Investigate America's renewed interest in wind power.

2. Investigate the plans for use of windmills to produce electricity and hydrogen for fuel by Dr. William Heronomus of the University of Massachusetts.

3. Describe the production of electricity by wind generators.

4. Design and construct a windmill.

ACTIVITY 8
(History, Science, Language Arts, Music, Art)

Objective: To discover the relationship between people and the sun throughout the ages.

Introducing the lesson:

1. Read to the class the song to the sun written by St. Francis of Assisi in 1224:

> "Praise to you, my Master, for all your creatures,
> Foremost for lordly Brother Sun
> Who lights our daytime for us.
> He is a beautiful thing who spreads forth a great splendor,
> Of You Most High, he is the visible emblem."

2. Ask: "Why have people through the ages felt such strong emotions when they contemplated the wonders of the sun?"

Developing the lesson:

1. Ask the students to comment on Henry Thoreau's comparison of daybreak and the rising of the sun with spiritual awakening.

2. Write a new verse to the John Denver song, "Sunshine."

3. Find two or more authors who have written about sun power and compare their descriptions of the sun.

4. Write a poem which expresses your feeling about the sun.

5. Investigate Inca worship of the sun.

6. Find pictures of the Inca temples to the sun "Father."

7. Find "Sun Fathers"in other cultures.

8. Investigate how the culture of the Sioux Indians looked beyond the power of the sun to people's responsibility to use it wisely, and discuss how well we have heeded the advice of the Sioux.

9. Read the following passage from the Papago Indian ceremony to the sun:

> "In the east is the house of the sun.
> Up over the top of his roof-beam
> The sun climbs and journeys
> Over the heads of us
> Who make our journey below him.
> I stretch my right hand sunward,
> Then trace upon my body
> The ritual sign."

(This ritual, called a "ciwiltkona," is performed by dancers who believe that they recharge themselves with the sun's energy as they circle a sand painting of the sun.)

Extending the lesson:

1. Ask the students to describe the warm red pulse of the sun; its light reaching them; their feelings as they watch its wonders of shore and sky.

2. Set the words of the "sun songs" to music.

3. Design a city that uses only solar energy.

4. Write haikus and cinquain poems about the sun. Here are some examples from Tampa students:

Haiku

Flow of Golden heat	(5 syllables)
So LARS can have hot water	(7 syllables)
To take a shower!	(5 syllables)

Cinquain

Jewel	(2 syllables)
Precious Treasure	(4 syllables)
Giving bright warm fuzzies	(6 syllables)
All day long to a smiling face	(8 syllables)
Sunshine	(2 syllables)

ACTIVITY 9
(Science, Social Studies, History)

Objective: To discover the relationship between the sun's energy and people's use of it.

Introducing the lesson:

1. People have used the energy of the sun through all of history. Ask: "Why do we use so little of the sun's radiant energy now?" (Energy comes to earth in very diffuse form, and concentrating it for use requires extensive and, so far, very expensive technology.)

2. Ask: "Do we use any of the sun's energy directly?" (only for evaporation and passive home heating)

2. Ask: "Why is there renewed interest in solar energy?" (Days of cheap fossil fuels are over. Uses of solar energy once considered too expensive are now no more expensive than other kinds of energy.)

Developing the lesson:

1. Investigate the use of direct solar energy in making salt by evaporation near San Francisco Bay.

2. Investigate the construction of solar furnaces by Felix Trombe in the French Pyrenees at Mont Louis. (3,500 mirrors focus on a small area, producing temperatures of over 6,000°F.)

3. Investigate efforts to produce solar cookers. (research of Mouchot, Dr. Abbott, etc.)

4. Ask: "Why have efforts to provide solar cookers to people in underdeveloped countries been generally unsuccessful?" (The cost is too high; even $10 is more than people can afford.)

5. Investigate the development and use of solar systems to heat swimming pools and household water in Florida.

6. Ask: "Why have solar furnaces not been used?" (Research for their development halted when cheap fossil fuels became available.)

Extending the lesson:

1. Read in an encyclopedia about people's search for and use of salt produced by natural evaporation. (Include Florida and other southern states during the Civil War.)

2. Ask: "How did the cultural eating habits of people in India and Mexico and other hot countries work against the hopes for use of solar cookers to replace cooking with scarce wood?" (They eat their big meal at night, not during the day, when a solar cooker could be used.)

ACTIVITY 10
(Science, Mathematics, Art, Social Studies, Language Arts)

Objective: To discover the relationship between direct solar energy and people's use of it.

Introducing the lesson:

1. Ask the students to suggest words that describe a farm. Write the words in columns on the chalkboard as fast as you hear them--make it a game to stay ahead of the students.

2. Read in the Meinels' book, "Power For the People," or in the NSTA Source Book about the Meinels' proposal to build a huge solar "farm" in the southwestern U. S.

Developing the lesson:

1. Investigate the cycle for capturing the sun's energy and using it. (Trap solar radiation in collectors; pump heat to a central power plant; generate steam; and produce electricity with steam turbines.)

2. Describe the "rows" on the Meinel farm. (These are rows of solar collectors with mirrors to focus sunlight on black pipes filled with liquid sodium to carry the heat. The whole collector is enclosed in a transparent evacuated half-cylinder.)

3. Ask: "What is the crop?" (heat--temperatures as high as 1,000°F.)

4. Ask: "What happens on cloudy days?" (Heated sodium flows to a storage tank which could hold heat for a few days and continue to generate electricity.)

5. Investigate how much electricity could be produced on a solar farm. (A farm of 10,000 square miles in size, 100 miles square, could produce half of the nation's need for electricity in the year 2000, according to the Meinels.

6. Ask: "Isn't that a lot of land to use?" (In the southwestern U.S., 10,000 square miles is only a tiny fraction of the relatively unused desert.)

7. How does the efficiency of a solar farm compare with that of a standard electric generating plant? (Both operate at about 30 percent efficiency, but the solar collecting equipment is fed by free fuel--sunshine.)

8. What other resources would be required to operate an energy farm of this size? (metals, glass, transmission lines, water)

Extending the lesson:

1. Discuss this use of direct solar energy by people.

2. Ask: "What could a development like the solar farm proposed by the Meinels mean for the future?" (It could assure cheap, plentiful electricity, although there would still be a great loss in transmission of electricity if all the solar farms were located in the southwestern U.S.)

3. Debate the feasibility of setting aside 10,000 square miles of Florida land for a solar farm. (Would it be just as good to use land for citrus farming?)

4. Identify other kinds of solar farms that are being considered. (various crops like quick-growing trees and starchy vegetables)

ACTIVITY 11
(Science, Social Studies, Art)

Objective: To discover the relationships between the various forms of energy.

Introducing the lesson:

1. Ask: "What does the term 'appropriate technology' mean?" (It is used by the U.S. Department of Energy to describe small-scale, energy-related technologies which are "appropriate" or adapted to local needs, skills, and available energy resources)

2. Discuss what appropriate technology might mean in Florida. (solar, wind, uses which enhance energy conservation, uses of existing technology)

Developing the lesson:

1. Congress has authorized a small grants program to encourage development of appropriate technology. Ask: "What would be the goals of such a program?"

2. Write to the Department of Energy, Southeast Region, 1655 Peachtree Street, N.E., Atlanta, Georgia 30309, for information on this small grants program.

3. Investigate the concept of "total energy" power system installations for schools and small communities.

4. Investigate problems with such installations. (Custom design and construction make them expensive; not as convenient as just turning on the power from utility.)

5. Is solar heating of water or space being used in your school? If not, why not? Develop a plan to use solar energy in your school.

Extending the lesson:

1. Design a class mural showing your community with a total energy power installation and solar collectors on every building.

2. Discuss the value of using renewable resources such as solar energy and wind (no supply problem--and they are free.)

3. Describe the effects on a community of a "total energy" program. (It encourages cooperation and self reliance.)

4. Design a plan which would make appropriate technology easier to adapt to local needs, skills, and energy availability.

5. Find out the number of days your community had winds strong enough to operate windmills.

ACTIVITY 12
(Science, Social Studies, Vocational-Technical)

Objective: To discover the relationship between energy and matter in organic materials.

Introducing the lesson:

1. How to get rid of our mountains of garbage has become an increasingly difficult problem for every community. Ask: "How does our community dispose of its wastes?"

2. Why don't we burn our organic wastes to produce power?

Developing the lesson:

1. Investigate the formation of methane. Why is it called natural gas? (Organic wastes--dead materials--are fermented by anaerobic bacteria, which grow in the absence of oxygen to form methane and carbon dioxide.)

2. Ask: "Why cannot people use this age-old natural method to dispose of their organic wastes?" (too many people and mountains of waste)

3. Find out how much waste is generated in your community.

4. Read about the work of Dr. Ram Bux Singh in designing and constructing "biogas" plants in India.

5. Investigate problems of using a community's sewage effluent in a biogas plant. (too much water, which reduces efficiency of the digester)

6. Discuss how cow manure from cattle feed lots could be used in biogas plants to reduce water pollution and waste of a valuable resource. (Kaplan project in Bartow, Florida)

7. Read about the research of Dr. Martin Wolf of the University of Pennsylvania in converting urban wastes to methane.

Extending the lesson:

1. Investigate whether or not your community sewage disposal system uses in anaerobic bacteria process. If so, is the methane it produces used to power the plant?

2. Investigate the supply problems of a biogas plant. (Major problem is transportation of wastes to the biogas plant.)

3. Consider the environmental costs of using animal manure for biogas production. (loss of valuable soil conditioner and fertilizer)

4. Compare energy production of leaves or grass with manure. (Leaves generate seven times as much methane. Remember entropy--the cow used most of the energy in the grass to make meat, so not much was left in the manure.)

5. Design a methane generator for your home or school.

6. Investigate the waste problems with a biogas plant. (Waste is sludge, undigested material, which may make up 40 percent of the total fuel. Disposal is a problem unless it is used as a fertilizer or soil conditioner.

ACTIVITY 13
(Science)

Objective: To discover the relationship between the sun's energy and its use for power.

Introducing the lesson:

1. Without solar cells for power, space vehicles and satellites could not be operated. What are solar cells? (tiny slices--wafers-of silicon, about 1½ inches square and only a few thousandths of an inch thick)

2. Solar cells are called "photovoltaic cells." What does photovoltaic mean? (photo = light; voltaic = electricity, named after Allesandro Volta)

Developing the lesson:

1. How does a solar cell produce electricity? (The silicon wafer is coated with boron to produce a positive electric layer which interacts with the negatively-charged silicon. When photons in sunlight strike the silicon cell, they are converted to electrons which flow to the boron layer, causing a flow of direct current, electricity.)

2. Why are solar cells so expensive? (Skilled hand labor is required in growing and cutting silicon crystals; more energy is used to manufacture cells then they can produce.)

3. Ask: "Is there any hope for solar cell use in power plants?" (Mass production of machine-made wafers from ribbons of silicon slices look promising.)

4. Investigate proposals by Dr. Peter Glaser for development of solar power plants in space.

5. Why are scientists concerned about the Glaser proposal? (It proposes to beam microwave electricity back to each receiver--could act as a death ray?)

Extending the lesson:

1. Investigate possible development of solar power plants on earth. (For the immediate future, it looks like a choice of nuclear and coal for fuel until the various solar technologies can be made economically feasible.)

2. Ask: "Why would a solar cell power plant be more efficient in space?" (It could be positioned to receive sun's rays 24 hours a day; no loss of solar radiation by reflection from clouds and atmosphere.)

3. Investigate the integration of solar cells with roofing materials. (General Electric has developed a shingle made from solar cells.)

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Non-Technical

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Technical

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Architectural

THE PASSIVE SOLAR ENERGY BOOK...E. Mazria; Rodale Press, Emmaus, PA 18049, 1979, 435 pp, $10.95. A complete guide to passive solar building and greenhouse design; includes rules of thumb for system calculations.

THIRTY ENERGY-EFFICIENT HOMES YOU CAN BUILD...A. Wade and N. Ewenstein; Rodale Press, Emmaus, PA 18049, 1977, 316 pp, $8.95. Designs of houses already constructed are presented for use by people building their own homes; solar designs are included.

Practical and Do-It-Yourself Projects

BUILD YOUR OWN SOLAR ENERGY SYSTEM...C. H. Breckenridge; Solar Heating Systems, 13584 49th Street North, Clearwater, FL 33520, 1976, 40 pp, $3.95.

BUILD YOUR OWN SOLAR WATER HEATER...Florida Conservation Foundation, Inc., 935 Orange Ave., Winter Park, FL 32789, 25 pp, $2.50.

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General Energy

ENERGY WE CAN LIVE WITH...D. Wallace; Rodale Press, Emmaus, PA 18049, 150 pp, $3.95. Analysis of the potentials and applications of alternative energy sources, including solar energy.

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SOFT ENERGY PATHS: TOWARD A DURABLE PEACE...A. R. Lovins, Ballinger Publishing Co., Cambridge, MA 02138, 1977, 234 pp. $6.95. Proposals for restructuring of our energy system and steps to putting renewable energy into action.

ENERGY FOR SURVIVAL...W. Clark; Anchor Press, New York, 1975. 652 pp, $12.50 (also available in paperback). Every teacher should have and use this book as a readable reference.

SOURCES OF ENERGY EDUCATION INFORMATION

ENERGY EDUCATION MATERIALS

Office of Environmental Education
Department of Education
Knott Building
Tallahassee, Florida 32301

Energy Management Center
Pasco County Schools
P.O. Box 190
Port Richey, FL 33568

Technical Information Center
Department of Energy
Post Office Box 62
Oak Ridge, Tennessee 37830

GENERAL INFORMATION

Florida Solar Energy Center
300 State Road 401
Cape Canaveral, FL 32920

Governor's Energy Office
The Capitol
Tallahassee, Florida 32301

Technical Information Center
Department of Energy
Post Office Box 62
Oak Ridge, Tennessee 37830

National Solar Heating and Cooling Center
Post Office Box 1607
Rockville, MD 20850